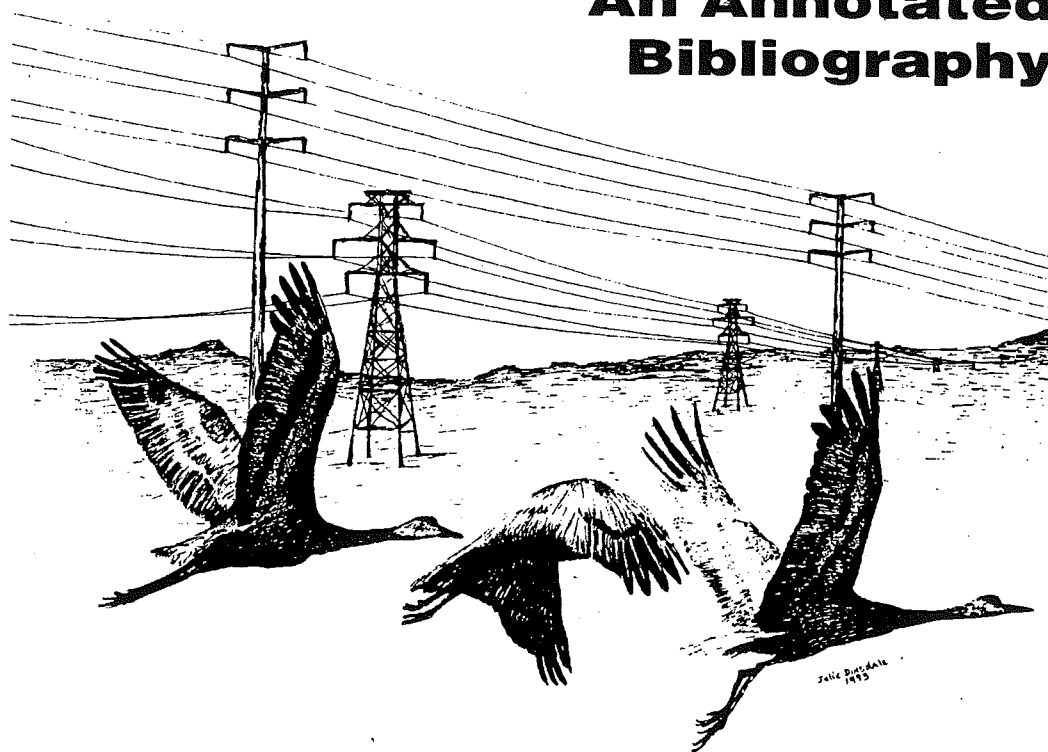


# AVIAN COLLISION AND ELECTROCUTION:

**An Annotated  
Bibliography**



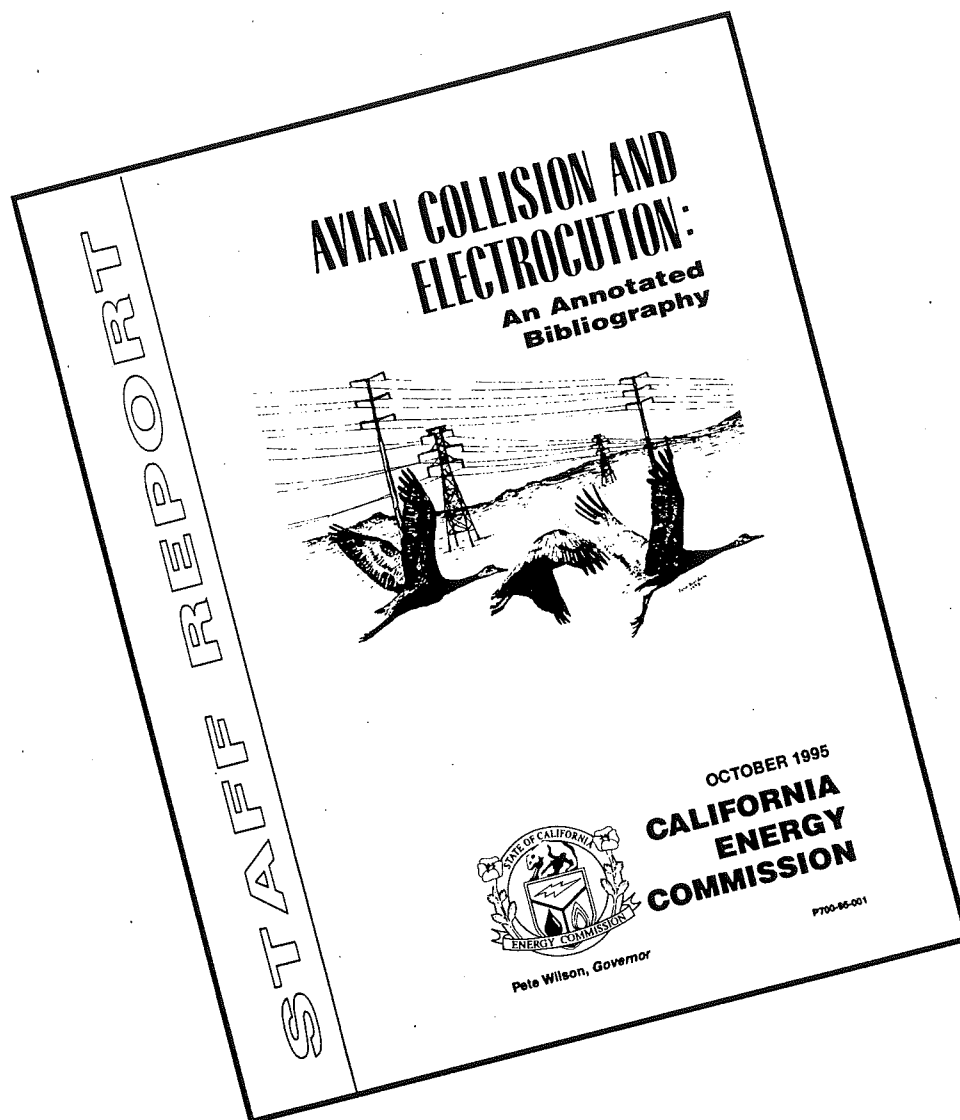
OCTOBER 1995



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COMMISSION**

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## ACKNOWLEDGEMENTS

The work on this annotated bibliography started in 1986 and progressed to completion with the assistance of several hard-working persons. We would like to acknowledge and thank these people for their efforts.

We are grateful to James Estep for the initial literature collection efforts. Over the years, Joan Humphrey, Martin Scheel, Katherine Bodeman-Wadsworth, and Dick Anderson continued the literature search. We could not have gathered such a diversity of books, reports, and articles without the dedicated and professional assistance of Diana Watkins and Mary Chilcote in the California Energy Commission's in-house library. We thank you all for your untiring efforts.

We also extend thanks to Tino Flores and Sue Foster of the California Energy Commission's Graphic Arts section for the cover design and final report format. We thank Julie Dinsdale for the cover artwork.

Finally, we thank Robert Haussler, James Brownell, Dave Maul, and Dick Anderson for their editing assistance and for their support and encouragement throughout this project.

## PREFACE

This annotated bibliography was initiated as a result of rising concern throughout the world about the losses of birds due to collisions with power lines and other wires, towers, wind turbines, and other structures, and from electrocution by power lines. We hope that the information contained in this bibliography will help reduce these unnecessary losses. This information can be used to improve the planning, structure configuration and design, siting location, and mitigation measures for new projects and for potential retrofit efforts where appropriate. These considerations would result in benefits to world bird populations and assist in avoiding costly delays and maintenance efforts resulting from bird collision and electrocution mortality. As the world's human population grows and development expands into rural and other undeveloped areas, the impact of engineered structures on bird populations becomes increasingly critical. I hope this annotated list will provide assistance to both those involved in the design and siting of these structures and those concerned about bird populations world-wide.

Richard L. Anderson  
Wildlife Biologist  
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Sacramento, CA  
September 20, 1994



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# AVIAN COLLISION AND ELECTROCUTION: AN ANNOTATED BIBLIOGRAPHY

## INTRODUCTION

This project was initiated in response to numerous inquiries regarding avian collisions and electrocution mortalities at human-made structures. Problems caused by avian electrocution and collision with power lines include costly power outages and wildlands fires. These problems can result in expensive maintenance and repair efforts, inconvenience for rate payers, and unnecessary losses of birds. Public concern over these issues can also delay permitting and affect the routing of new facilities. Several state and federal laws may be enforced which could result in costly structural modifications of existing and new facilities.

Concerns regarding the causes and extent of avian mortality, locations of recurring incidents, and potential solutions have not always been adequately considered in the past. This compilation of literature on avian mortality will assist those industry and agency planners and researchers concerned with avoiding and resolving existing and future impacts of projects on avian species.

This bibliography contains entries mainly from 1876 to 1992, and the majority are from the United States. Most entries are taken from journals or periodicals, conference proceedings, government documents, private publications, utility company reports, books, academic theses, and newspaper articles. Copies of all items included in this bibliography are on file in the California Energy Commission's Environmental Protection Office.

Unless otherwise noted, each item was read and annotated. Special attention was given to the following aspects of the reports: numbers of individual birds and species killed or injured, contributing factors, habitat and other locational characteristics, and design features of the structures which resulted in injuries or death.

Other annotated bibliographies on the subject of avian mortality at human-made structures are currently available. Two such documents from the U.S. Fish and Wildlife Service were used extensively for this publication; entries originating therefrom are noted by asterisks ("\*" denotes Avery et al. 1978; "\*\*\*" denotes Avery et al. 1980). The intent for this bibliography is to present an up-to-date compilation of the most significant articles available on the subject; periodic updates and reprinting of this report are planned. Please send notification of additional references and errors to "Avian Collision and Electrocution: An Annotated Bibliography" to the California Energy Commission, MS #40, 1516 9th Street, Sacramento, California 95814, USA. Suggestions to improve the format are also welcome.

## USE OF INDICES

This annotated bibliography contains 468 citations of literature from the United States and other countries. Much of the literature selected discusses avian collision mortality with power lines, wind turbines, towers, or other structures. Other literature was selected for its discussion of avian species affected by electrocution. Non-English-language reports are included when an English summary was available.

This bibliography's format, modeled after Avery *et al.* (1978, 1980), is designed to be as efficient and as user-friendly as possible. Citations are indexed by subject matter, kinds of birds, locations, and authors; subject categories are broad and include the type of structures involved and the major topics discussed in the articles. The types of birds (taxonomic) are indexed according to family (*e.g.*, warblers) or group (*e.g.*, shorebirds). United States incidents are indexed by state within U.S. Fish and Wildlife Service regional boundaries, and incidents outside the United States are indexed under Africa, Asia, Australia and New Zealand, Canada, Europe, Pacific Isles, and South America and the West Indies.

## ALPHABETICAL LISTING BY AUTHOR

1. **Able, K.P. 1966. Television tower mortality near Louisville. Kentucky Warbler 42(2):27-28.**

Five kills totaling 25 birds of 16 species occurred at a 973-foot tower in Kentucky during fall 1965 in association with low pressure systems and frontal activity.

2. **\*Able, K.P. 1973. The changing seasons. American Birds 27(1):19-23.**

In fall 1972, single night kills exceeding 1,000 birds occurred at TV towers in Tennessee and Florida, and two events occurred at the floodlit chimneys of the Lanais, Ontario, Canada, power plant.

3. **Airola, D. 1987. Bird abundance and movements at the Potrero Hills wind turbine site, Solano County, California. Prepared for the Solano County Department of Environmental Management, Fairfield, California. Prepared by Jones and Stokes Associates, Sacramento, California. 43 pp.**

"The proposed wind turbine site at the Potrero Hills, Solano County [California], was studied to determine use of the area by waterfowl, other waterbirds, raptors, and songbirds, and to assess potential for project-related impacts." Primary flight altitudes for the various bird groups were estimated through observations. Birds, especially raptors, songbirds, and gulls, often flew below the 30 m height of the proposed turbines, and collisions were determined likely for some species. The author finds the sites adequate as experimental and control sites for future monitoring if turbines are installed.

4. **Alameda, Contra Costa, and Solano Counties, California. 1988. Request for proposals: a study of wind turbine effects on avian activity and habitat use. 17 pp.**

This request for proposal represents a joint effort by Alameda, Contra Costa, and Solano Counties (California) "to provide information necessary for predicting and mitigating the potential impact to avifauna resulting from wind turbine construction and operation in wind resource areas." A summary of a California Energy Commission (CEC) workshop on wind turbine effects on avian activity and habitat use is included.

5. **\*Alsop, F.J., III and G.O. Wallace. 1969. Spring tower-kill in Knox County. Migrant 40(3):57-58.**

Twenty casualties (ten species) were collected at the WTKV tower in Tennessee following the night of 7-8 May, 1969. A list of the losses is given including measurements of weight, length, tail, bill, tarsus, and gonad size. Weather data are also included.

6. **\*Andersen-Harild, P. and D. Block. 1972. Birds killed by overhead wires in some localities in Denmark. Dansk orn. Foren. Tidsskr. 67:15-23. (In Danish; English summary.)**

During October 1971, bird losses were monitored along 13.1 km of power lines (60 kV, 150 kV, and smaller overhead wires) at four locations in Denmark. Most of the lines crossed reed beds or shallow water areas. Of the 105 casualties, 80 percent were found directly beneath the wires. The most lethal of the four sites had a "wall of wires" configuration (twelve wires at eight different levels) and averaged nine recovered birds per 24 hours per ten km of power line. About 60 percent of the total losses were of species nesting in the area (herons, ducks, shorebirds, gulls) and 40 percent were migrants (moorhens, owls, thrushes, starlings, songbirds). Swans, gulls, and certain shorebirds were particularly vulnerable but ducks were killed in relatively low numbers. One species of bittern that was involved, *Botaurus stellaris*, is close to extinction in Denmark. Overhead wire systems should be regarded "as part of the correlation of the environmental factors which have a negative effect on bird populations."

7. **Anderson, A.H. 1933. Electrocution of purple martins. Condor 35(1):204.**

This article is an account of one male and one female purple martin found electrocuted by a power line at an irrigation reservoir near Tucson, Arizona.

8. **Anderson, R.L., and J.A. Estep. 1988. Wind energy development in California: impacts, mitigation, monitoring, and planning. California Energy Commission, Sacramento. 12 pp.**

Of 147 documented avian collision and electrocution incidents at California wind energy facilities from 1985 to 1988, 101 have been raptors. Of these, 34 were eagles and 58 were hawks. In the Altamont Pass, an average of 11 eagle and 17 hawk incidents occurred annually. Ninety-one percent of all documented avian mortality incidents resulted in mortality. This mortality information identified the need for further studies to better understand and resolve biological effects of wind projects.

9. **Anderson, S.H., K. Mann, and H.H. Shugart, Jr. 1977. The effect of transmission-line corridors on bird populations. American Midland Naturalist 97(1):216-221.**

"Observations of bird populations were made along transmission-line corridors of four different widths (12, 30.5, 61, 91.5 m) in areas in which the transmission line rights-of-way traversed typical eastern Tennessee deciduous forest." Detailed grid-mapping of individual bird sightings was done. The 12-meter corridors showed reduced species diversity while the 30.5-m corridor had high bird density and diversity. Wider corridors "were less diverse but attracted several open country bird species not characteristic of surrounding forest." The forest habitat had the highest species diversity.

10. **\*Anderson, W.L. 1978. Waterfowl collisions with power lines at a coal-fired power plant. Wildlife Society Bulletin 6(2):77-83.**

An estimated 400 birds per fall season (0.4 percent of the peak number present) were killed by colliding with overhead power lines at the Lake Sangchris/Kincaid, Illinois, power plant during 1973-75. Blue-winged teal were the most vulnerable and mallards the least vulnerable to collisions. Factors believed to be responsible for losses include the number and species of birds present, lack of visibility of the lines, disturbances that startle birds into flight, and the degree of familiarity of the birds with the area. To reduce waterfowl losses in general, it is recommended that lines not be built over water, that lines not cross places where waterfowl are known to congregate, that the visibility of lines be enhanced, and that waterfowl not be disturbed in the vicinity of existing lines.

11. **Anderson, W.W. 1975. Pole changes keep eagles flying. Transmission and Distribution 27:28-31.**

Proliferation across the United States of high voltage transmission lines is considered a significant cause for the dwindling eagle population due to electrocution. In 1973, an estimated 300 golden eagles died on the country's power lines; 98 percent were young birds just learning to fly. "It was found that electrocution occurred exclusively on a single pole crossarm type construction where the conductors were nearly horizontal and had insufficient spacing." Golden eagles preferred poles where the crossarm was perpendicular to the prevailing wind and in a commanding topographical position. This can be taken into account by the power company to reduce the number of poles requiring modification. Tower nesting sites are a benefit of power lines to eagles in areas where other natural nest sites do not occur. Rather than destroying tower eyries, line workers can trim long sticks used in nest-building to clear the conductor and prevent outages.

12. **Anonymous. 1954. Disaster in migration. Chat 18(4):104-105.**

On 7 October 1954, a "rain" of small birds at several spots in the Southeast occurred. In Charleston, South Carolina, about 100 dead birds of 24 species were identified, and in Winston-Salem, North Carolina, 190 birds of 21 species were collected from near the respective airport ceilometers. Most of these birds were warblers. The catastrophe was attributed to a combination of "tumbling temperatures, overcast skies, ... stabbing beacons," and a cross-wind associated with a cold front.

13. **\*Anonymous. 1961. Large bird kills at TV towers. Bluebird 28(1):9.**

A brief summary of two kills in Missouri is given: 658 birds (41 species) and one red bat at Columbia, on 24 September 1960, and about 100 birds (at least 16 species) at Cape Girardeau on 27 September 1960.

14. **Anonymous. 1973. Eagle electrocution study underway. Idaho Wildlife Review (Sept./Oct.):16.**

A collaborative study by six Western state utility companies looked at power lines and eagle electrocutions. The research indicated that some eagle deaths were from being shot then electrocuted; in one area, "15 of 17 apparent electrocutions turned out to be shootings." Recommended measures for preventing electrocution include shortening the ground wires that run down utility poles to earth, covering transformers and other energized parts, replacing steel crossarm braces with wood braces, and lowering or lengthening a crossarm.

15. **Anonymous. 1978. Management recommendations - raptors. Unpublished in-house document, California Energy Commission, Sacramento. 37 pp.**

This series of three annotated bibliographies lists documents dealing with electrocution and collision deaths of raptors, siting of power lines, and mitigation measures. Raptor mortality is cited as an impact to be considered in siting power lines; particularly problematic are lines on migration routes and near wintering grounds, resting areas, and communal roosts. Mitigation and management considerations are cited from various studies including environmental documents for power line and power plant construction. Recommendations include identifying utility pole structures causing the most electrocutions and increasing line visibility by attaching highly visible markers.

16. **Anonymous. 1981. 500-kV towers are for the birds. Electrical World 195(7):27.**

Large platforms were installed on Pacific Power and Light Company's 500-kV Oregon-Idaho AC line to prevent birds from nesting on the crossarm lattice members of utility poles and to protect insulators from excrement contamination and flashovers. The platforms became preferred nest sites for eagles.

17. **\*Arend, P.H. 1970. The ecological impact of transmission lines on the wildlife of San Francisco Bay. Prepared by Wildlife Associates for Pacific Gas & Electric (PG&E), San Ramon, California. 24 pp.**

This study of selected Pacific Gas and Electric steel tower transmission lines was conducted during June, July, and August 1970. While observing that "a few ducks obviously did occasionally hit the power lines," the author concludes, "...there can be no doubt that, qualitatively, the steel tower transmission line ecologically enhances rather than detracts from the wildlife environment."

18. **Armbruster, M.J. 1990. Characterization of habitat used by whooping cranes during migration. U.S. Fish and Wildlife Service Report 90(4).**

Power lines were identified as influencing whooping cranes in their selection of roosting sites near rivers and wetlands in Nebraska. Participants in a workshop on this topic felt that power lines should be treated as a potential mortality factor for cranes with the minimum width of affected area at no less than 100 m.

19. **\*Arnold, J.R. 1960. Black rail in San Joaquin Valley of California. Condor 62(5):405.**

A black rail was found dead on 26 August 1959 near Stockton, California, having apparently struck a fence or an overhead wire.

20. **\*Aronoff, A. 1949. The September migration tragedy. Linnaean Newsletter 3(1):1-2.**

Mortality at the Empire State Building (over 200 birds, 30 species) on the night of 10 September 1948 is discussed, and a species list is provided. Also discussed are kills at a Nashville, Tennessee, airport ceilometer involving 248 birds of 35 species; at a Philadelphia, Pennsylvania, building (at least 11 species); and at a 450-foot tower in Baltimore, Maryland. A list of casualties from the Nashville incident is included.

21. **Asplundh Environmental Services. 1979. Right-of-way ecological effects bibliography. Prepared for the Electric Power Research Institute, Palo Alto, California. EA-1080. Research Project 855-1. 246 pp.**

This annotated bibliography contains 824 citations of documents describing ecological effects of overhead transmission line rights-of-way. The citations are indexed according to author, subject, and ecological region. Forty documents on bird mortality are included.

22. **Association of Bay Area Governments. 1987. Small but powerful: a review guide to small alternative energy projects for California local decisions. Oakland, California. 66 pp.**

Bird collisions and electrocutions with wind turbines and associated wires are cited as wind energy development impacts. "Although bird mortality rates are relatively low, even these rates may be significant for endangered raptors," notably the California condor, peregrine falcon, and bald eagle. Power lines near water have been found to be more hazardous than in other areas. Appropriate mitigation measures are discussed and techniques for protecting birds are given. Special attention is given to the California condor as a major source of conflict with wind farm development.

23. **\*Avery, M. and T. Clement. 1972. Bird mortality at four towers in eastern North Dakota: Fall 1972. Prairie Naturalist 4(3/4):87-95.**

During fall 1972, 561 dead birds (88 species) and five red bats were collected at four towers in North Dakota, two of which exceed 2,000 feet and are reportedly the tallest in the world. (The species most frequently killed at the Omega tower, farther south and west than the other three towers, were characteristic of marsh and prairie grassland areas. Species killed near the other three towers were characteristic of forest and forest edge habitats.) Species lists of the casualties are given and scavenger activity at the sites is discussed.



24. **\*Avery, M., P.F. Springer, and J.F. Cassel. 1977. Weather influences on nocturnal bird mortality at a North Dakota tower. *Wilson Bulletin* 89(2):291-299.**

Mortality at the 366-meter Omega tower in North Dakota in 1972 and 1973 is examined relative to nightly cloud and wind conditions. Most fall losses occurred under overcast skies associated with the passage of cold fronts as migrant species milled about the tower. However, 58 percent of the spring losses took place on non-overcast nights, mainly through collisions with outlying guy wires: rails and fringillids were killed mostly on non-overcast nights, while warblers died in greater numbers on overcast nights; warblers tended to be killed much closer to the central, lighted structure than were fringillids; and non-passerines suffered substantially greater losses far from the tower than did passerines, especially on non-overcast nights. Behavioral differences noted by other investigators are included as well.

25. **Avery, M.L., ed. 1978. Impacts of transmission lines on birds in flight: proceedings of a workshop. Oak Ridge Associated Universities, Oak Ridge, Tennessee. 31 January - 2 February 1978. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-78/48. 151 pp.**

Three major issues regarding the impact of transmission lines on birds are addressed: the magnitude of the problem, possible short-term solutions, and future (long-term) approaches. The proceedings include papers on migratory behavior and flight patterns, mitigation through engineering and design modification, studies of Bonneville Power Administration lines, impacts on waterfowl and eagles, transmission line engineering and its relationship to migratory birds, transmission line routes through water habitats, and a case study of the Klamath Basin. References, summaries, and a list of participants are included.

26. **Avery, M.L., P.F. Springer, and N.S. Dailey. 1978. Avian mortality at man-made structures: an annotated bibliography. U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team. FWS/OBS-78/58. 108 pp.**

This bibliography on avian mortality and human-made structures contains 853 international entries. Citations are indexed according to subjects, kinds of birds, and locations. "The majority of the reports include the number of individuals and species killed, with some observations of weather conditions at the time of the incident, bird behavior near the structure, or comments on the attraction of birds to lights."

27. **Avery, M.L., P.F. Springer, and N.S. Dailey. 1980. Avian mortality at man-made structures: an annotated bibliography (revised). U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team. FWS/OBS-80/54. 152 pp.**

This revised version of the 1978 bibliography contains 189 new international annotations for a total of 1,042 entries. Citations are indexed according to subjects, kinds of birds, and locations. "The majority of the reports include the number of individuals and species

killed, with some observations of weather conditions at the time of the incident, bird behavior near the structure, or comments on the attraction of birds to lights."

28. **\*Bagg, A.M. 1957. The changing seasons. Audubon Field Notes 11(4):312-325.**

Avian mortality in spring at towers in Jacksonville (300 birds) and Leon County (46 birds, 14 species), Florida, are mentioned.

29. **\*Bagg, A.M. 1965. The changing seasons; spring migrants: the few and the many. Audubon Field Notes 19(4):438-446.**

On the night of 26 April 1965, in thick fog, 150-175 birds landed on the deck of a tanker off the New Jersey coast. The only casualties were 23 Cape May warblers that apparently struck the ship's superstructure.

30. **\*Bagg, A.M. 1969. The changing seasons. Audubon Field Notes 23(1):4-12.**

During September and October 1968, kills were reported from towers in Manitoba, Canada, and the states of Wisconsin, New York, Ohio, Tennessee (1,800 ovenbirds among the casualties at Nashville), and Florida (853 birds of 80 species at WCTV near Tallahassee).

31. **\*Bagg, A.M. 1971. The changing seasons. American Birds 25(1):16-23.**

Lists are given for 55 species killed during late September at the Empire State Building and eight towers in the eastern U.S.

32. **\*Bagg, A.M. and R.P. Emery. 1964. The fall migration: northeastern maritime region. Audubon Field Notes 18(1):7-17.**

The casualties (over 488 birds, mostly warblers) and weather at a lighthouse in the Bay of Fundy during fall 1963 are discussed at length.

33. **Baglien, J.W. 1975. Biology and habitat requirements of the nesting golden eagle in southwestern Montana. Thesis. Montana State University, Bozeman. 53 pp.**

During the study (1972-1974), one bald eagle and one golden eagle were electrocuted during spring at power poles along the Madison Valley floor. The power poles may be considered preferred perching sites only during the wintering and spring seasons. Artificial perches were not found to be attractive to birds in mountainous areas where natural perches such as trees or rock outcroppings were readily available.

34. **\*Bailey, A.M. 1929. Bird casualties. Wilson Bulletin 41(2):106-107.**

Two female woodcocks died from collisions, one against a building and the other with an overhead wire. A black-footed albatross on Laysan Island struck a wire and broke its leg.

35. **\*Baird, J. 1962. The changing seasons: a summary of the fall migration. Audubon Field Notes 16(1):4-6.**

Over 10,000 collision casualties were reported from around the country during fall 1961. A tower in Eau Claire, Wisconsin, caused 5,097 of these casualties while two TV towers in Boston, Massachusetts, caused very few. Reports of negative findings are urged.

36. **\*Baird, J. 1964. The changing seasons. Audubon Field Notes 18(1):4-6.**

During fall 1963, 33,406 birds were reported killed at towers and 488 at lighthouses in the United States and Canada. Most losses resulted from a single cold front that passed through Minnesota and southern Ontario during 18-21 September.

37. **\*Baird, J., R.I. Emery, and R. Emery. 1959. Fall migration: northeastern maritime region. Audubon Field Notes 13(1):11-13.**

In Massachusetts, on the night of 19 September 1958, over 300 birds (mostly warblers and vireos) were killed at two Boston TV towers and over 200 (mostly warblers and flycatchers) died at a Springfield searchlight.

38. **\*Ball, R.E. 1973. Bird mortality at towers in Marysville, Missouri: Fall 1972. Transactions, Missouri Academy of Science 7/8:294.**

Three small towers (250, 400, and 408 feet tall) were checked for dead birds from 5 September to 16 November 1972. No large single-night kills were recorded, and altogether 71 birds of 33 species, mostly sparrows, were recovered. Most were believed to have collided with guy wires rather than the towers themselves. (Abstr.)

39. **\*Bamberg, J.B., R. Warriner, H.O. Todd, and H.C. Monk. 1935. Nocturnal migration in stormy weather. Migrant 6(4):77-80.**

Birds heard and seen at an illuminated 100-foot water tower while migrating through Tennessee in poor weather are discussed. About 50 birds (10 species) were found dead in this late October incident.

40. **\*Banko, W.E. 1960. The trumpeter swan: its history, habits, and population in the United States. U.S. Fish and Wildlife Service, Washington, D.C. 214 pp.**

Known trumpeter swan accidents seemed to be confined largely to striking power, telephone, or fence wires in flight. Most swan collisions with overhead cables and fences occurred during winter fogs. Five instances of wire collisions in Montana are mentioned; four out of five strikes were fatal.

41. **Banks, R.C. 1979. Human related mortality of birds in the United States. U.S. Fish and Wildlife Service, Washington, D.C. Special Scientific Report: Wildlife No. 215. 16 pp.**

Reports of mass mortality at radio and TV towers usually occur as a result of a particular weather pattern affecting a geographic area. Most reports of avian mortality at towers are based on single incidents of mass death, or at best, recoveries of dead birds over a short period of time. These are considered of little value in establishing an estimate of the number of birds that may be killed on an annual basis under "normal" conditions (*i.e.*, "a single instance of spectacular mass mortality may far exceed the normal annual mortality"). Several studies cited support an annual mortality rate of 2,500 birds per tower on average.

42. **\*Barbour, R.W. 1961. An unusual bird mortality at Lexington. Kentucky Warbler 37(3):55.**

Following the stormy night of 7 May 1961, 82 dead birds (21 species) were collected at a 670-foot tower in Lexington, Kentucky.

43. **Batten, L.A. 1978. The seasonal distribution of recoveries and causes of blackbird mortality. Bird Study 25(1):23-31.**

"Miscellaneous accidents" -- including "flew into power cables or telephone wires" -- were reported for 12,885 adult blackbird recoveries from 1909 to 1970 in Great Britain. Fewer birds were found dead during winter months.

44. **\*Baumgartner, F.M. 1959. Fall migration: southern Great Plains region. Audubon Field Notes 13(1):43-45.**

On 11 October 1958, "a large box of birds" including marsh and sedge wrens was picked up at a TV tower in Dallas, Texas.

45. **\*Baumgartner, F.M. 1961. Fall migration: southern Great Plains region. Audubon Field Notes 15(1):54-56.**

On 22 October 1960, of eleven yellow rails found beneath a Dallas, Texas, TV tower, eight were dead and three were injured.

46. **\*Baumgartner, F.M. 1963. Fall migration: southern Great Plains region. Audubon Field Notes 17(1):45-46.**

An unspecified number of birds were killed at an Oklahoma City, Oklahoma, TV tower in September 1962.

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47. **Beaulaurier, D.L. 1981. Mitigation of bird collisions with transmission lines. Bonneville Power Administration, Portland, Oregon. 83 pp.**

"In this study removal of overhead groundwires was evaluated as a technique for mitigating bird collisions with transmission lines." Two sites were utilized: Lower Crab Creek, Washington (a 500-kV single circuit line), and Bybee Lake in Portland, Oregon (a 230-kV double circuit line). "Earlier studies at these sites had documented small but measurable collision rates (*i.e.*, number of collisions per number of flights) attributed primarily to collisions with groundwires." From fieldwork conducted October 1980 through March 1981, a total of seven dead birds and eight feather spots were found after groundwire removal; species included green-winged teal, northern pintail, greater scaup, American wigeon, glaucous-winged gull, European starling, red-winged blackbird, and song sparrow. "During pre-removal studies at these two sites, a total of 53 dead birds and 22 feather spots were found over two years of study." Collision rates in every case were less after groundwire removal; for both sites studied, the average reduction in bird collision mortality was approximately one-half. Although methodologies differed among studies, wire marking seemed to reduce collision mortality about as effectively as groundwire removal (average reduction of 45 percent) where comparisons were possible. Airway marker balls and/or high intensity lights may cause decreased bird use of nearby habitat. It is important that markers do not cause wind or ice loading which can interfere with line reliability.

48. **Beaulaurier, D.L., B.W. James, P.A. Jackson, J.R. Meyer, and J.M. Lee, Jr. 1982.**

Mitigating the incidence of bird collisions with transmission lines. Pages 539-550 in: Third Annual International Symposium on Environmental Concerns in Rights-of-Way Management, San Diego, California, 15-18 February 1982. State College, Mississippi.

Mortality was measurable at five of twelve transmission line sections studied "but was not a biologically significant cause of avian mortality." A prior study by Bonneville Power Administration showed that birds collided primarily with small-diameter overhead groundwires. These wires were removed from three lines to assess the effect on collision rates. Groundwire removal appeared to reduce collisions by about one-half. This is comparable to reductions attributed to marking of groundwires in other studies. "Because removal of groundwires is not practical in many cases, further development and testing of the effectiveness of various marking techniques is needed." A table of results of different studies marking groundwires and conductors is included.

49. **Beecham, J.J. and M.N. Kochert. 1975. Breeding biology of the golden eagle in southwestern Idaho. Wilson Bulletin 87(4):506-513.**

Cause of death was determined for golden eagles found along the Snake River canyon in southwestern Idaho from 1968 to 1971. Of 28 birds recovered, twelve were immature eagles found electrocuted.

50. Belisle, A.A., W.L. Reichel, L.N. Locke, T.G. Lamont, R.M. Prouty, R.B. DeWolf, and E. Cromartie. 1972. Residues in fish, wildlife, and estuaries: residues of organo- chlorine pesticides, polychlorinated biphenyls, and mercury. *Pesticides Monitoring Journal* 6(3):133-138.

Twenty-eight bald eagle carcasses were collected in 1969 and 11 in 1970 from 13 states to be analyzed for pesticide residues. Of these, four were concluded to have died from "impact" and two from electrocution.

51. Bellrose, F.C. 1971. The distribution of nocturnal migrants in the airspace. *Auk* 88(2): 397-424.

Following the overcast night of 30 September 1965, ten birds of eight species were picked up at a TV transmission tower near Peoria, Illinois.

52. \*Benning, W.E. 1978. Region 3: Finger Lakes. *Kingbird* 28(1):42-44.

During the cloudy, rainy period of 20-24 September 1977, a record 3,862 birds were found dead at the Elmira, New York, TV tower. On the night of 19 September alone, 1,817 birds of 39 species were collected. Of the 48 total species, 24 were warblers.

53. Benson, P.C. 1980. Large raptor electrocution and powerpole utilization: a study in six western states. *Raptor Research (Winter)*:125-126.

Subadult age classes of raptors suffer greater mortalities due to inexperience in flight ability and hunting methods. Habitat and season can have an effect on mortality rates. Hunting methods can affect electrocution risk: more electrocutions occur where the main prey base is cottontail rabbits than jackrabbits. More eagles were electrocuted in winter when snow caused feather-wetting and the birds "still-hunted" (perched and waited for prey to appear). The author recommends that pole configurations be modified where needed.

54. Benson, P.C. and J.C. Dobbs. 1985. Collisions of cape vultures (*Gyps coprotheres*) with towers. Annual Meeting, Raptor Research Foundation, Sacramento, California, 9 November 1985.

Forty-nine cape vulture carcasses were found at the base of a tower at the Kransberg (Republic of South Africa) vulture colony. Orange spheres were attached to the guy wires "to warn the vultures" and during the following fledging season, collisions decreased.

55. \*Benton, A.H. 1954. Relationships of birds to power and communication lines. *Kingbird* 4(3):65-66.

While acknowledging some losses of birds due to collisions with overhead wires, the author states that "power and communication lines now represent a valuable asset to bird life" in the form of nest and perch sites.

56. **\*Bernard, R.F. 1966. Fall migration: western Great Lakes region. Audubon Field Notes 20(1):45-46, 50-53.**

On 6 September 1965, 7,085 dead birds (55 species) were collected at a tower near Eau Claire, Wisconsin. At least 500 birds died by striking lighted windows and a neon sign near Newberry, Michigan, on 26 September.

57. **\*Bierly, M.L. 1973. 1971 fall television tower casualties in Nashville. Migrant 44(1):5-6.**

In what was described as an "average season," 990 birds (52 species) died at the WSM tower and 135 (24 species) at WSIX in Nashville, Tennessee.

58. **\*Bijleveld, M.F.I.J. and P. Goeldlin. 1976. Electrocutation d'un couple de Buses. Nos Oiseaux 33(6):280-281.**

A pair of hawks was electrocuted at a 17-kV power line in Switzerland.

59. **BioSystems Analysis, Inc. 1990. Wind turbine effects on the activities, habitat, and death rate of birds. Prepared for Alameda, Contra Costa, and Solano Counties, California. 2 pp.**

A two-year study to evaluate the extent and significance of the impact of wind turbines on bird life was started in 1989 in Altamont Pass, California. The study site included about 16 percent of the approximately 7,000 turbines in the Pass. One hundred fourteen dead birds were found between February 1989 and February 1990. Eighty-one were raptors, the majority of which were red-tailed hawks, American kestrels, and golden eagles. Sixty-three percent of all deaths were attributed to turbine collision, 12 percent to electrocution, 5 percent to wire collision, and 20 percent to unknown causes. Most deaths resulted from amputation injuries. "It was estimated that over 300 raptors were killed by windfarm-related injuries within the Altamont Pass area during the first year of study (1989-1990)."

60. **Blake, C.H. 1958. Skull injuries at a TV tower. Chat (September):71.**

Following the overcast night of 11 May 1958, ten freshly-killed passerines were picked up at the WUNC-TV tower in Hillsboro, North Carolina. Location of the carcasses suggested that "the birds were hitting the tower itself and not the guy wires and were deflected in falling by light wind from the southwest." Seven of the birds had skull injuries, including hemorrhages, suggesting a considerable proportion of glancing blows.

61. **\*Blokpoel, H. and D.R.M. Hatch. 1976. Snow geese, disturbed by aircraft, crash into power lines. Canadian Field Naturalist 90(2):195.**

On 8 May 1974, several thousand snow and blue geese were feeding in a stubble field in Manitoba, Canada, when a low-flying aircraft caused them to take wing. In the "chaotic" rush into the air, 25-75 birds were killed or injured by striking power lines that



bordered one side of the field. It is not known whether death resulted from collision or electrocution.

62. **Bochkovskii, B.B., E.I. Udod, A.N. Sherentsis, and N.V. Yasinskaya. 1983. Protecting power lines against spark-over caused by large birds. Soviet Power Engineering 12(4):397-404.**

Spark-overs (called 'flashovers' in the U.S.) were causing widespread power outages in 110- to 330-kV overhead lines in the Ukraine during summer. These electrical discharges passed from the utility pole crossbeam to a conductor via accumulated excrement from storks. This report includes recommendations for protecting the lines from storks and other large birds mainly by erection of special barriers to prevent birds from landing near insulators. Bird barrier design sketches are included.

63. **\*Boeker, E.L. and P.R. Nickerson. 1975. Raptor electrocutions. Wildlife Society Bulletin 3(2):79-81.**

Use of power line poles by raptors depends on topography, prey abundance, and availability of natural perches. "Electrocutions are most critical in states with the largest eagle populations -- primarily the mountainous western states." During 1969-71, over 300 eagles died by electrocution in the western United States. Documented losses of raptors in 1972 and 1973 throughout the country totalled 281, 250 of which were golden eagles. Many victims were young birds and nearly all deaths occurred on small distribution lines where conductors were three to four feet apart. Particularly troublesome stretches of line were modified to alleviate the hazard.

64. **Bohm, R.T. 1988. Three bald eagle nests on a Minnesota transmission line. Journal of Raptor Research 22(1):34.**

One nest in 1986 and two in 1987 were found on 250-kV DC transmission lines. Each nest fledged two young successfully, was between 21 and 24 m from the ground, and was within one km of a lake or river. "An increasing bald eagle population, a lack of natural nest sites and a proliferation of transmission lines may interact to influence eagle use of powerlines in future years."

65. **Bonneville Power Administration. 1987. Cape Blanco wind farm feasibility study: final report. U.S. Department of Energy. Portland, Oregon. DOE/BP-11191-14. 187 pp.**

Bird collision with wind turbines and transmission lines is discussed in this assessment of wind energy development impacts. Collisions with turbines are likely, with weather, flight altitude, and number and height of operating turbines as contributing factors. Turbine collisions are most likely to occur during the first two hours of night at the initiation of migration (climbing altitude). Because of limited visibility and increased collisions at night, the impact on nocturnal migrant populations is a primary concern. The author concludes that bird avoidance behavior is likely to be high (about 95 percent) over the Cape Blanco Wind Farm.

66. **Borell, A.E. 1939. Telephone wires fatal to sage grouse. Condor 41(1):85-86.**

Three dead sage grouse were found beneath telephone lines paralleling a road north of Beaver, Utah. It appeared that the collisions occurred as the birds flew back and forth from alfalfa pastures and grain fields to the sagebrush-covered mesas on the other side of the road.

67. **Boshoff, A. and C. Fabricius. 1986. Black eagles nesting on man-made structures. Bokmakierie 38(3):67-70.**

The authors believed this to be the first report of black eagles, *Aquila verreauxii*, nesting on human-made structures. Several eagles were found electrocuted in 1984 and 1985 at a communications tower near Hopetown, South Africa. Subsequent attention to the matter of bird use of towers for nesting resulted in greater awareness "of the need to preserve raptor nests on ... structures and to keep disturbance to an absolute minimum during the critical stages of the breeding season."

68. **\*Boso, B. 1965. Bird casualties at a southeastern Kansas TV tower. Transactions of the Kansas Academy of Science 68(1):131-136.**

The 1,200-foot KOAM-TV tower in Kansas was checked regularly for dead birds during the fall of 1963 (75 birds, 35 species) and spring 1964 (50 birds, 14 species). A species list, weather on the days of collection, and the distribution of casualties about the tower are given.

69. **\*Boyd, H. 1961. Reported casualties to ringed ducks in the spring and summer. Wildfowl Trust 12th Annual Report:144-146.**

Overhead wire collision was identified as the cause of death for 17 British-banded ducks (mostly mallard and teal species) recovered from March to August (no year given). In all, 87 "accidental" deaths were recorded. About 70 percent of the ducks killed were males.

70. **\*Boyd, H. and M. Ogilvie. 1964. Losses of mute swans in England in the winter of 1962-63. Wildfowl Trust 15th Annual Report:37-39.**

Losses of mute swans due to collisions with overhead wires were abnormally low in January and February 1963, accounting for only 35 of the 264 reported deaths.

71. **Brady, A. 1969. An electrocuted great horned owl. Cassinia 51:57.**

An owl was found clutching a Norway rat and hanging from a power line in early November 1968 at Mechanicsville, Pennsylvania. The incident occurred presumably when the rat held by the owl touched the wire below the owl's perch and created a short circuit.

72. **\*Breckenridge, W.J. 1958. Fall migration: western Great Lakes region. Audubon Field Notes 12(1):32-33.**

Between 31 August and 20 September 1957, three large kills were reported at a new 1,000-foot tower in Eau Claire, Wisconsin. The 2,972 casualties (42 species) found on 20 September included 23 species of warblers.

73. **\*Breckenridge, W.J. 1959. Spring migration: western Great Lakes region. Audubon Field Notes 13(4):371-373.**

On 17 May, 284 birds were killed from colliding with a TV tower in Detroit, Michigan.

74. **\*Brewer, R. and J.A. Ellis. 1958. An analysis of migrating birds killed at a television tower in east-central Illinois, September 1955-May 1957. Auk 75(4):400-414.**

This is a comprehensive account of the occurrence of avian mortality resulting from impacts with a 983-foot tower near Champaign, Illinois. Analysis of seven mortality incidents includes species lists (486 dead birds, 51 species), weather data, comparisons with kills elsewhere, sex, age, and fat content of birds collected, spatial distribution of the carcasses around the tower, and a discussion of the attraction of birds to the tower.

75. **Bromby, R. 1981. Killer lines in Colorado present an electrocution hazard for raptors. Colorado Division of Wildlife, Wildlife News 6(3).**

This report cites a Utah study in which 529 eagle carcasses were found under 250 miles of power lines. Of the 69 carcasses fresh enough to determine the cause of death, 58 had been electrocuted, 10 had been shot, and one had struck a power line. The author notes that entanglement of birds by loosely wrapped wires has surfaced as a major problem in recent years. "Killer wires" are described as those with loose wrapping of wire, short crossarms, ground wires that run to the top of the pole, and metal cross braces.

76. **Brown, L. 1976. British Birds of Prey: a study of Britain's 24 diurnal raptors. N N Collins, London.**

This study indicates that wire collision is the most common single cause of accidental death of merlins in England.

77. **Brown, W.M., R.C. Drewien, and E.G. Bizeau. 1987. Mortality of cranes and waterfowl from power line collisions in the San Luis Valley, Colorado. Pages 128-135 in: Proceedings of the 4th Crane Workshop, 1985. Platte River Whooping Crane Habitat Maintenance Trust, Grand Island, Nebraska.**

The authors recommend that no new transmission lines be placed within two km of traditional roost or feeding sites. The static wire (the nonconducting topmost wire on a power line used to minimize power outages from lightning strikes) is normally smaller than the conductors and appears to be the wire most often struck by birds in flight.

Static wire removal is recommended whenever possible, but modification and/or better marking are preferred methods.

78. **\*Browne, M.M. and W. Post. 1972. Black rails hit a television tower at Raleigh, North Carolina. Wilson Bulletin 84(4):491-492.**

A black rail was found dead at the 1,175-foot WRAL tower in Raleigh, North Carolina, on 19 September 1969 and another on 27 September 1970.

79. **\*\*Byrd, V., J. Sincock, and T. Telfer. 1978. The status of Newell's manx shearwater, a threatened species. Page 80 in: Pacific Seabird Group 5th Annual Meeting, Asilomar, California, 13-16 December. Pacific Seabird Group, Stinson Beach, California.**

On Kauai, Hawaii, shearwaters are susceptible to collisions with human-made objects such as power lines, buildings, and cars after being blinded by bright lights. This problem is worsening annually due to increased tourism and the resulting development and traffic.

80. **Byrne, S. 1983. Bird movements and collision mortality at a large horizontal axis wind turbine. Cal-Neva Wildlife Transactions:76-83.**

This study was conducted as a part of Pacific Gas and Electric Company's performance monitoring program for a Boeing MOD-2 wind turbine located at the edge of Suisun Marsh in Solano County, California. Bird mortality was monitored for one year beginning in September 1982. As of January 1, 1983, five dead birds had been found at the turbine site.

81. **\*Caldwell, L.D. and N.L. Cuthbert. 1963. Bird mortality at television towers near Cadillac, Michigan. Jack-Pine Warbler 41(2):80-89.**

From 26 September to 16 October 1961, 812 birds (42 species) were collected at the 1,295-foot WWTV tower near Cadillac, Michigan. A comparison index revealed the fall mortality to be most like the kills reported from Nashville, Tennessee, and Eau Claire, Wisconsin. In spring 1962, 74 birds (27 species) were found at WWTV and 125 (36 species) were collected from a nearby 1,130-foot tower. The species composition was markedly different from the fall.

82. **\*Caldwell, L.D. and G.J. Wallace. 1966. Collections of migrating birds at Michigan television towers. Jack-Pine Warbler 44(3):117-123.**

The spring and fall species composition of dead birds found from 1959 to 1964 at seven sites are analyzed. Towers within 30 miles of each other had virtually the same species composition, while greater diversity of species occurred between more distant towers. Spring and fall species compositions were markedly different, possibly due to different migration routes for various species. Warblers and thrushes were the most common casualties.

83. **\*Carter, J.H., III, and J.F. Parnell. 1976. TV tower kills in eastern North Carolina. Chat 40(1):1-9.**

A large bird kill occurred in October 1970 (over 1,000 birds, 39 species) at the 1,994-foot WECT tower in North Carolina. In fall 1971 and 1972, regular checks (after the passage of cold fronts and after mostly cloudy nights) were made at WECT and at the 1,188-foot tower 30 miles away. Losses in 1971 (2,683 birds) were typically associated with the passage of cold fronts when low ceilings and north winds prevailed. In 1972, cold fronts passed quickly through the area and only 387 casualties were found. The authors note that many carcasses were no doubt overlooked in the vegetation at the tower sites and there was much evidence of predator/scavenger activity. A combined annotated species list is given.

84. **\*Case, L.D., H. Cruickshank, A.E. Ellis, and W.F. White. 1965. Weather causes heavy bird mortality. Florida Naturalist 38(1):29-30.**

In early October 1964, 4,707 birds (37 species) were killed by striking brightly lit buildings, towers, cars, and other obstacles in Florida. "Clouds of birds" were reported circling buildings. Weather consisted of a low cloud ceiling, drizzle, and northerly winds. Warblers accounted for 98.7 percent of the casualties.

85. **Cassel, J.F., D.W. Kiel, J.J. Knodel, and J.M. Wiehe. 1979. Relation of birds to certain power lines in central North Dakota. Zoology Department, North Dakota State University, Fargo. Prepared for the United Power Association, Environment and Lands Division, Elk River, Minnesota. 50 pp.**

Searches for dead birds were conducted under two 230-kV transmission lines in North Dakota. One was an old line and the other was recently relocated to a wetland/slough area. In fall 1977, 15 birds were found at the old line; in spring 1978, 17 were found at the old line and 21 at the new line; in fall 1978, 17 were found at the old line and 30 at the new. Impacts of the two lines are compared. The authors conclude that the new line "provides no greater hazard" than the old. "Although birds flying in the vicinity of the transmission lines studied did seem to be aware of the lines, the lines seem to provide little threat to their welfare."

86. **\*Chamberlain, B.R. 1955. Fall migration: southern Atlantic coast region. Audubon Field Notes 9(1):17-18.**

Heavy mortality at beacons, towers, ceilometers, and lighted windows was reported from several southeastern (U.S.) cities in October 1954. Red-eyed vireos and ovenbirds were the most common species.

87. **\*Chamberlain, B.R. 1957. Fall migration: southern Atlantic coast region. Audubon Field Notes 11(1): 15-18.**

About 2,500 birds, mostly warblers, were killed at the Chapel Hill, North Carolina, TV tower on 28-29 September 1956.

88. **\*Chamberlain, B.R. 1958. Fall migration: southern Atlantic coast region. Audubon Field Notes 12(1):19-21.**

During fall 1957, over 1,100 birds (80 species) were killed at an Aiken, South Carolina, tower. Smaller kills were reported from Raleigh and Charlotte, North Carolina, and Camp Cornelia and Atlanta, Georgia.

89. **\*Chamberlain, B.R. 1961. Fall migration: southern Atlantic coast region. Audubon Field Notes 15(1):23-26.**

From 28 September to 2 October 1960, tower casualties in Charlotte, North Carolina, exceeded 340 birds. Smaller kills were reported during 8-17 October.

90. **Clausen, B. and F. Gudmundsson. 1981. Causes of mortality among free-ranging gyrfalcons in Iceland. Journal of Wildlife Diseases 17(1):105-109.**

Four dead gyrfalcons (of 38 studied at the Museum of Natural History in Reykjavik, Iceland) were found under telephone lines with fractured sternums or wings.

91. **\*Cochran, W.W. and R.R. Graber. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bulletin 70(4):378-380.**

Counts of flight calls on two nights at a 984-foot tower near Champaign, Illinois, indicated that migrants were concentrated in the vicinity of the structure. Turning off the red warning lights on the tower eliminated the aggregation. This article was the first to provide any experimental evidence that nocturnal migrants actually congregate around the red warning lights on towers.

92. **\*Coffey, B.B., Jr. 1964. Two bird kills at WMC-TV, Memphis. Migrant 35(2):53.**

On 7 and 8 May 1961, 19 dead warblers and vireos (11 species) were collected at the WMC-TV tower in Memphis, Tennessee. A second incident involving 99 birds (21 species), including 57 red-eyed vireos, occurred on 11 May 1964.

93. **\*Cohen, D.A., ed. 1896. California department. Osprey 1(1):15.**

On 15 May, 14 red phalaropes and one ruddy duck were found dead near a telegraph line. Autopsies indicated that the birds had died from collisions with the overhead wire.

94. **Colton, H.S. 1945. An unusual accident to a broad-tailed hummingbird. Plateau 18(15):15.**

A broad-tailed hummingbird struck a radio aerial wire with great enough force to be stuck by its bill. It died because it could not escape from the tightly twisted copper wire strands. The incident, reported in Flagstaff, Arizona, in 1944, most likely occurred during a courtship flight.

95. Coon, N.C., L.N. Locke, E. Cromartie, and W.L. Reichel. 1970. Causes of bald eagle mortality, 1960-1965. *Journal of Wildlife Diseases* 6:72-76.

Of 55 bald eagles that died of injuries during this U.S. study, seven had impact injuries, one was electrocuted, and 45 had been shot.

96. Cornwell, G., and H.A. Hochbaum. 1971. Collisions with wires - a source of anatid mortality. *Wilson Bulletin* 83(3):305-306.

A female pintail was found impaled on a barbed wire fence on 15 August 1966 in the Portage la Prairie, Manitoba, Canada, Community Pasture. An adult blue-winged teal drake was found in a barbed wire fence in August 1966 in North Dakota. Other incidences included a drake pintail entangled by the neck from two telephone wires in July 1948 in Saskatchewan, Canada, and a female blue-winged teal impaled on a barbed wire fence. The authors note that barbed wire fences and overhead wires commonly kill ducks, but such incidents are seldom reported. It is recommended that barbed wire fences no longer needed be "removed from publicly-owned waterfowl production marshes; and, when overhead wires become a frequent local source of mortality, they should be placed under-ground or moved." Also, siting of fences and lines through marshes needs to be reevaluated.

97. \*Cornwell, G.W. 1968. Needless duck deaths. *Conservation Catalyst* 2(4):15-18.

Data of 2,000,000 examples of non-hunting-related waterfowl mortality (including collision mortalities) in the U.S. and Canada were compiled. About half of 3,000 non-hunting deaths were due to striking wires. The author recommends that wires in areas of high waterfowl use be buried.

98. \*Cottam, C. 1929. A shower of grebes. *Condor* 31(1):80-81.

Hundreds of eared grebes died by striking wires, houses, and trees after being forced to fly low in a snowstorm in Caliente, Nevada, in December 1928.

99. Coues, E. 1876. The destruction of birds by telegraph wire. *American Naturalist* 10(12):734-736.

In a three-mile stretch between Cheyenne, Wyoming, and Denver, Colorado, Coues counted over 100 dead birds, mostly horned larks, lying beneath the telegraph line. Three birds were actually seen striking the wires. The larks exhibited some hesitation and confusion in flight when flocks crossed the wires. The author states, "Usually, a remedy has been or may be provided for any unnecessary or undesirable destruction of birds; but there seems to be none in this instance. Since we cannot conveniently abolish the telegraph, we must be content with fewer birds."

100. Council of Europe. 1981. Birds in need of special protection in Europe. Nature and Environment Series No. 24. Strasbourg, France. 154 pp.

Widespread power line collision is mentioned as a reason for the decline of eagle owls (*Bubo bubo*) in Europe. White storks (*Ciconia ciconia*) are also prone to overhead wire collision. Both species are given "vulnerable" status.

101. Craig, T.H. 1978. A car survey of raptors in southeastern Idaho 1974-1976. Raptor Research 12(1/2):40-45.

A survey of raptors was conducted by car over a 187 km route in southeastern Idaho during the non-nesting seasons from November 1974 to May 1976. Rough-legged hawks were the most numerous observed, followed by American kestrels and golden eagles. Perched raptors were commonly seen on power poles: 75.1 percent of rough-legged hawks, 94 percent of prairie falcons, 80.4 percent of American kestrels, and 73.7 percent of golden eagles. American kestrels preferred pole tops or wires; most golden eagles preferred the tops and crossarms.

102. \*Crawford, R.L. 1971. Predation on birds killed at TV tower. Oriole 36(4):33-35.

To test the effects of scavengers at the WCTV tower near Tallahassee, Florida, 157 marked dead birds were placed out over a period of five nights. The nightly loss of test birds to scavengers was between 64 percent and 100 percent. The author concludes that serious attention must be paid to the predator/scavenger problem at towers if meaningful data are to be obtained.

103. \*Crawford, R.L. 1974. Bird casualties at a Leon County, Florida TV tower: October 1966-September 1973. Tall Timbers Research Station Bulletin No. 18. Tallahassee, Florida. 27 pp.

During the seven years covered in this report, over 5,500 casualties and seven new species were collected at the WCTV tower in Florida, bringing the total losses to about 35,000 (177 species) in 18 years of continuous monitoring. Monthly species lists are given for the last seven years, and the total kill is presented by spring and fall months for each year 1955-1973. Much of this report is devoted to the problem of scavengers removing tower casualties. An extensive literature review is included in the introduction.

104. \*Crawford, R.L. 1976. Some old records of TV tower kills from southwest Georgia. Oriole 41(4): 45-51.

This article presents previously unreported data, originally collected by H.L. Stoddard, Sr., and R.A. Norris, on bird losses at the WALB and WRBL-WTVM towers in southwestern Georgia. On 28 visits to the WALB tower from 1959 to 1963, 613 birds (no total species count) were collected. Many of the carcasses were disturbed by scavengers, and tall grass around the station grounds made it impossible to find birds over much of the area. Frontal activity and other weather conditions associated with kills on 12-13 September 1959, 7-8 September 1962, and 17-18 October 1962 are described.



The species composition between kills at WALB and WCTV in Tallahassee, Florida (about 80 km SW), were significantly similar on the first two nights, but not on the third. Species lists for the three dates at both towers are given. Two kills were recorded at the WRBL-WTVM tower: 18 birds on 23 April and 60 on 18 September 1962.

105. **Crawford, R.L. 1978. Autumn bird casualties at a northwest Florida TV tower: 1973-1975. *Wilson Bulletin* 90(3):335-345.**

In fall 1973, 261 individuals of 57 species were collected at the 308-meter WCTV tower at Tall Timbers Research Station, Leon County, Florida. The following fall, 1,832 dead birds (87 species) were gathered. In 1975, 1,771 of 90 species were collected, totaling 3,864 individuals of 109 species for the three autumns. Age and sex classes were noted. In 1974 and 1975, a rigorous program of predator control was instituted.

106. **\*Cunningham, R.L. 1964a. Fall migration: Florida region. *Audubon Field Notes* 18(1):24-28.**

In September 1963, in Leon County, Florida, the largest kill ever (no data given) at the WFSU tower was reported. At the WCTV tower, 735 birds, including 80 bobolinks, were killed.

107. **\*Cunningham, R.L. 1964b. Spring migration: Florida region. *Audubon Field Notes* 18(4):442-446.**

In Leon County, Florida, 207 birds, including 150 thrushes, were found dead at the WCTV tower. The WFSU tower had small mortality numbers during the spring.

108. **\*Cunningham, R.L. 1965. Fall migration: Florida region. *Audubon Field Notes* 19(1):28-33.**

Following the drizzly, hazy night of 6 October 1964, 4,707 birds (37 species) were found dead near the Indian River in Florida, the result of low-flying birds striking buildings, headlights and windshields; 98 percent were warblers (1,354 common yellowthroats and 322 blackpolls). Also, "moderate" bird kills were reported at towers in Daytona Beach and St. Augustine. Over 2,000 birds were killed during 6-8 October at two TV towers in Jacksonville; 95 percent of these fatalities were warblers.

109. **Dawson, B. 1974. Letting them go: great horned owls go to school. *Museum Talk* 48(2):45-48.**

The Bird of Prey Survival Project at San Francisco Zoological Gardens has a ward with two golden eagles, each with a wing missing due to power line collision.

110. Dean, W.R.J. 1975. Martial eagles nesting on high tension pylons. *Ostrich* 46(1):116-117.

In the Kimberley area of the Cape Province, South Africa, martial eagles (*Polemaetus bellicosus*) have been recorded as nesting on high tension pylons. The nests were all in woodlands, although tree sites were available. In the Ottoshoop area of the western Transvaal, a tawny eagle (*Aquila rapax*) was recorded nesting on a high tension pylon.

111. Dedon, M., S. Byrne, J. Aycrigg, and P. Hartman. 1989. Bird mortality in relation to the Mare Island 115-kV transmission line: progress report 1988/1989. Prepared by Technical and Ecological Services. Prepared for Department of the Navy, Western Division, Naval Facilities Engineering Command, Office of Environmental Management, San Bruno, California. Report 443-89.3. 150 pp.

The area surrounding the 115-kV transmission line serving the Mare Island Naval Shipyard in California was searched for associated bird mortalities from August 1988 through June 1989. Scavenging and predation biases are mentioned. During the study, 242 birds were collected in the salt evaporation pond transect and 68 birds and one bat were collected in the hay field transect, totaling 43 species. Correcting for scavenging and habitat biases showed that total estimated bird mortality associated with the power line was 310 for the hay field transect and 724 for the salt pond transect. The most common species collected were ruddy duck, western sandpiper, black-bellied plover, western meadowlark, and red-winged blackbird. A control transect produced 80 specimens of 15 species. The authors conclude that the "numerous dead birds found in this transect support the conclusion that collision mortality represents a small amount of the total mortality of the local bird populations." Overall mortality was high at times of low visibility and low during periods of "unsettling weather." Recommendations include improving sampling techniques and using more objective search bias tests, more frequent scavenger tests, and better vegetation control. A bird flight pattern study is recommended to provide perspective for mortality information and to learn which conductors contribute most to collisions. Suggestions to reduce bird mortalities due to power line collisions include the use of aerial markers, tree planting adjacent to the transmission line, and undergrounding the power line.

112. Dedon, M., P. Hartman, S. Byrne, and S.A. Laymon. 1990. Bird mortality in relation to the Mare Island 115-kV transmission line: progress report 1989/1990. Prepared by Technical and Ecological Services. Prepared for Department of the Navy, Western Division, Naval Facilities Engineering Command, Office of Environmental Management, San Bruno, California. Report 443-90.4. 100 pp.

In the second year of monitoring at this California site, 259 birds (53 species) were collected. Accounting for predation and scavenging biases, 334 birds were estimated to be killed by the transmission line in the hay field transect and 923 in the salt pond transect. Species found most were black-bellied plover, ruddy duck, western sandpiper, dunlin, savannah sparrow, and western meadowlark, accounting for 54 percent of all identified specimens. Two black rails (listed as threatened in California) were found. During the day, passerines generally flew below the height of the lower distribution lines

and non-passerines flew mostly above the 115-kV transmission line. The authors recommend continuing surveys and implementing a study to assess the effectiveness of power line markers for reducing bird collisions. This 115-kV line is adjacent to wetlands frequented by birds.

113. **Dennis, R. 1990. Birds and conservation problems of the high tops. North of Scotland Royal Society for the Protection of Birds (RSPB). Munloch, Ross and Cromarty, Scotland. 4 pp.**

Mountain birds of the "high tops" of Scotland include ptarmigan, dotterel, and snow bunting. Ski developments threaten the best habitats for the rarest birds. "The threats to birds can be direct, such as damage to the environment and its vegetation, changes in snowbed vegetation due to compaction, disturbance by large numbers of people and deaths due to collisions with overhead wires." The author feels that proposed projects for skiing expansion in the Cairngorm National Nature Reserve be stopped to protect the High Tops from further damage.

114. **\*Devitt, O. 1967. The birds of Simcoe County, Ontario. Brereton Field Naturalists' Club, Barrie, Ontario, Canada. 190 pp.**

Kills at the CKVR-TV tower at Barrie, Ontario, Canada, during 1960-67 are discussed. The numbers of deaths seemed to vary directly with the prevalence of fog and low ceiling during migration. In the seven years covered, 2,632 dead birds (63 species) were collected. The majority killed were thrushes, warblers, flycatchers and sparrows; a complete list is given.

115. **Devlin, J.M. 1954. Effects of weather on nocturnal migration as seen from one observation point at Philadelphia. Wilson Bulletin 66(2):93-101.**

Three hundred avian migrants were killed on the night of 21-22 September 1953 when they crashed against the Empire State Building in New York City. The author notes that this event illustrates what happens if migrants on a following wind meet a warm front with strong southerly winds and are forced to fly very low under the frontal slope.

116. **\*Dickinson, L.E. 1957. Utilities and birds. Audubon Magazine 59(2):54-55, 86-87.**

The author reviews the problem of bird strikes and electrocutions at power lines in the U.S. and cites examples of solutions to particular situations.

117. **\*Dilger, W.C. 1954. Electrocution of parakeets at Agra, India. Condor 56(2):102-103.**

Rose-ringed parakeets were frequently electrocuted on power lines at an Army base at Agra, India, in the 1940s.

118. \*d'Ombrian, A.F. 1945. Migratory birds and overhead wires. *Emu* 45(2):173-174.

Migrating shorebirds "become mystified by the bright city lights" which cause them to fly lower than usual, resulting in collisions with overhead wires. Two instances of mortality in Australia are recounted.

119. Drager, T. and J. Linthicum, eds. 1985. Peregrine falcon wild nest management, hack sites, and cross-foster operations. Santa Cruz Predatory Bird Research Group. University of California, Santa Cruz.

A female peregrine falcon was reported to have collided with a power line. No apparent injury resulted.

120. \*Drewien, R. 1973. Ecology of Rocky Mountain greater sandhill cranes. Dissertation. University of Idaho, Moscow. 82 pp.

Collisions with power lines accounted for 37 percent of the observed sandhill crane mortality in the population that was studied in the western U.S.

121. \*Dunbar, R.J. 1954. Bird mortality - Oak Ridge. *Migrant* 25(4):63-64.

On the morning of 7 October, 1954, about 1,000 birds (22 species) were found dead on a parking lot at Oak Ridge, Tennessee. Losses were attributed to collisions with overhead power lines, light towers, cars, and pavement. Most carcasses were found beneath the parking lot lights.

122. Dunstan, T.C. 1968. Breeding success of osprey in Minnesota from 1963 to 1968. *Loon* (Dec.):109-112.

The author discusses contributing factors of osprey mortality in Minnesota. Osprey sometimes nest on utility poles at the crossbars. A nestling and an adult were found electrocuted at two different nest sites.

123. Dunstan, T.C., J.H. Harper, and K.B. Phipps. 1978. Final report: habitat use and hunting strategies of prairie falcons, red-tailed hawks, and golden eagles. Prepared for U.S. Bureau of Land Management, Denver, Colorado. Contract 52500-CT5-1013. 177 pp.

Still-hunting from utility and power line poles and crossbars, trees, fence posts, shrubs, rocks, and the ground was the most extensively used prey-search technique for prairie falcons, red-tailed hawks, and golden eagles during the study.

124. **\*Eaton, S.W. 1967. Recent tower kills in upstate New York. Kingbird 17(3):142-147.**

Bird mortality from collisions with towers on the Allegheny Plateau in New York is discussed, including a list of 57 species found dead during 1956. The author estimates that 10,000 songbirds are killed annually from tower collision in the area.

125. **Edeburn, R.M. 1973. Great horned owl impaled on barbed wire. Wilson Bulletin 85(4):478.**

A great horned owl was found dead, impaled at the base of its left wing on a barbed wire fence, in summer 1972 in Mercer, Pennsylvania.

126. **\*Edscorn, J.B. 1974. The fall migration: Florida region. American Birds 28(1):40-44.**

The unusually low kill at the WCTV tower near Tallahassee, Florida, in fall 1973 was attributed to very clear weather.

127. **\*Edscorn, J.B. 1975. The fall migration: Florida region. American Birds 29(1):44-48.**

Included among the fall 1974 casualties at the WCTV tower in Florida were 971 birds on the night of 17 October.

128. **\*Elder, W.H. and J. Hansen. 1967. Bird mortality at KOMU-TV tower, Columbia, Missouri, fall 1965 and 1966. Bluebird 34(1):3-7.**

A list of 851 dead birds (36 species) found in fall 1965 and 1966 at KOMU-TV, Columbia, Missouri, is given, with age and sex data on seven species from 1966. Some comparisons with data from other towers are included.

129. **Electric Power Research Institute. 1982. Prevention of golden eagle electrocution. EPRI EA-2680, Project 1002 Final Report. Palo Alto, California. 90 pp.**

Eagle electrocutions were documented in six western United States by examining carcasses found below power lines; of the 416 birds found, 82.5 percent were golden eagles. This report analyzes species and age of electrocuted birds, temporal occurrences, abundance of raptors, raptor prey, vegetation, topography, soil, weather, and other related factors. "Measures found to lower incidences of eagle electrocution include routing lines around preferred prey habitat, locating power lines in topographically low areas, and insulating conductors on corner and transformer poles."

130. Elkins, N. 1988. Weather and bird behavior. Second edition. T. & A.D. Poyser, Calton, Staffordshire, England. 239 pp.

Bird mortality caused by inclement weather and collision with power lines and other structures is briefly discussed. "This happens most frequently to nocturnal migrants in dense fog or cloud accompanied by precipitation. The refraction and reflection of light by water droplets increase the sphere of illumination and confuse the migrants.... The effects of adverse weather are more pronounced for birds that are deformed, injured, diseased, or heavily parasitized, and these individuals are invariably the first to die in a stress situation. Resistance of healthy birds may be lowered by sudden and large temperature changes. There is evidence of a sex difference in the ability to resist these changes; females appear to be hardier, particularly in polygamous species."

131. Ellis, D.H., J.G. Goodwin, Jr., and J.R. Hunt. 1978. Wildlife and electric power transmission. In: J.L. Fletcher and R.G. Busnel, eds. Effects of noise on wildlife. Academic Press, Inc., New York. 305 pp.

Electrocution is noted as a significant cause of eagle mortality in the western U.S. and of the cape vulture (*Gyps coprotheres*) in southern Africa. Ravens, eagles, hawks, and occasionally other birds use local power line towers for nest sites. Wild turkeys (*Meleagris gallopavo*) heavily utilize towers and even conductors as roost sites in west Texas. The authors recommend that key locations where birds are especially vulnerable (e.g., mountain passes along important migration corridors) should be avoided in siting power lines. Problem areas need to be identified and corrected.

132. Ellis, D.H., D.G. Smith, and J.R. Murphy. 1969. Studies on raptor mortality in western Utah. Great Basin Naturalist 29(3):165-167.

The majority of raptor mortalities are from shootings. A significant number can also be attributed to power line electrocution.

133. Eltringham, S.K. 1963. The British population of the mute swan in 1961. Bird Study 10(1):10-28.

Power disruption and mortality of mute swans in Britain are discussed. The author recommends re-siting the cables away from regular swan routes and increasing cable visibility in order to reduce collisions and power black-outs.

134. Emerson, W.O. 1904. Destruction of birds by wires. Condor 6(1):37.

The author discusses power line collision mortality of shorebirds and a black rail in the San Francisco Bay area, particularly in salt marshes and evaporating ponds, noting "the disastrous effect upon bird life of numerous telephone, telegraph, and electric power wires strung along highways" and across lines of migration or favorite paths to feeding grounds. The death of a great horned owl on a barbed wire fence is noted.

135. **Enderson, J.H. and M.N. Kirven. 1979. Peregrine falcon foraging study in the geysers: Calistoga known geothermal resource area, Sonoma County, California. Prepared for the U.S. Bureau of Land Management. Prepared by Department of Biology, Colorado College, Colorado Springs, Colorado. 17 pp.**

Power transmission lines are a hazard to peregrine falcons because their attack dives may exceed 150 mph. "Collisions with wires are well-known: at least six occurred in California in recent years ... and in 1978 in Colorado a young Peregrine struck a power line 2 km from its eyrie and suffered a broken wing."

136. **Estep, J.A. 1989. Avian mortality at large wind energy facilities in California: identification of a problem. California Energy Commission, Sacramento. P700-89-001. 30 pp.**

Avian mortality data resulting from collision or electrocution with wind energy-related structures were solicited and compiled from a variety of sources in 1988. The incidents occurred between November 1984 and April 1988 at Altamont Pass and Tehachapi Pass, California. One hundred eight raptors of seven species were reported. Causes of mortality, injuries, age class, season, and other results are discussed.

137. **Faanes, C.A. 1987. Bird behavior and mortality in relation to power lines in prairie habitats. U.S. Fish and Wildlife Service. Fish and Wildlife Technology Report 7. 24 pp.**

In this study of two spring and two fall migration periods between July 1980 and May 1982, 633 birds were found dead beneath 9.6 km of power lines. The total kill was estimated at 1,332 birds, with higher mortality rates during the fall migration. Overhead ground wires were responsible for most of the deaths. Diving ducks appeared to experience fewer problems near power lines than dabbling ducks. While none of the observed mortality was considered biologically significant at the sites studied, the cumulative effect of avian collision mortality may be important, particularly to populations of rare or endangered birds. Power lines 400 m or more from the edge of the water generally had lower observed mortality than sites with closer lines. Avian mortality in riparian habitat may increase when power lines are at or below the forest canopy, probably due to decreased visibility.

138. **\*Farnham, C.B., Jr. 1971. Snipe impaled on cable. Kingbird 21(1):10-11.**

In New York, a common snipe died when its lower mandible pierced the insulation of a telephone wire and could not get free.

139. **\*Feehan, J. 1963. Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at the Ostrander television tower. Flicker 35(4):111-112.**

A list of 1,250 birds (28 species) killed in Minnesota on a cloudy night in September 1963 is presented.

140. Ferrer, M. and M. De La Riva. 1987. Impact of power lines on the population of birds of prey in the Donana National Park and its environment. Mediterranean Birds of Prey III. National Institute of Game Biology 12. (English summary.)

This study took place in the marshes of the Guadalquivir River in southern Spain from 1982 to 1983. Mortality variations throughout the year were reported along 100 km of power lines in this area, which has great importance as one of the last refuges of the Spanish imperial eagle. More than 100 birds of prey carcasses (13 species) were collected including *Aquila adalberti*, *Gyps fulvus*, and *Circaetus gallicus*. Because 70 percent or so of the bodies were lost before recovery, the actual number of raptor mortalities could reach 400 per year. Factors influencing the death rate include precipitation, wind, relative humidity, landscape characteristics, pattern of utility towers, and position of insulators. Electrocution was shown to be one of the main causes of imperial eagle mortality.

141. Ferrer, M., M. De La Riva, and J. Castroviejo. 1991. Electrocution of raptors on power lines in southwestern Spain. Journal of Field Ornithology 62(2):181-190. (English summary.)

A study conducted at Donana National Park in Spain revealed that within a 100 km sector of power lines, 233 dead raptors (13 species) were found. It is estimated that about 400 raptors per year die along this section of lines. Deaths from wire collision accounted for 2.8 percent of the total mortality during the study. Electrocution is the primary known cause of death for the endangered Spanish imperial eagle (*Aquila adalberti*). Mortality rates differed with changes in habitat quality. Those areas with more human-altered habitat exhibited lower mortality rates from electrocution, while areas with more natural habitat exhibited higher rates. The authors recommend the use of suspended insulators so that the wing tips of a perched bird cannot contact both phases at once. "[O]n metal pylons the position of insulators is an extremely critical factor affecting raptor mortality rates."

142. \*Fisher, H.I. 1966. Midway's deadly antennas. Audubon Magazine 68(4):220-223.

The effects of numerous antennas and guy cables on Midway Island's colony of Laysan albatrosses are discussed. At least 2,901 were killed in a 7-month period. Damage to other species is also mentioned.

143. \*Fisher, H.I. 1970. The death of Midway's antennas. Audubon Magazine 72(1):62-63.

Antennas on Midway Island were responsible for the deaths of more than 3,000 Laysan albatrosses in 1964 and 1965. Avian collision deaths stopped after the antennas were removed.



144. **\*Fitzner, R.E. 1975. Owl mortality on fences and utility lines. Raptor Research 9(3/4):55-57.**

In Washington and Idaho during the winter of 1973-74, the author found one great horned owl and one short-eared owl impaled on barbed wire fences and two short-eared owls hanging from overhead utility wires.

145. **Fitzner, R.E., W.H. Rickard, L.L. Cadwell, and L.E. Rogers. 1981. Raptors of the Hanford site and nearby areas of southcentral Washington. Prepared by Pacific Northwest Laboratory, Richland, Washington. Prepared for the Department of Energy and Rockwell Hanford Operations. Contract DE-AC06-76RLO 1830. 61 pp.**

At Hanford, Washington, red-tailed hawks nested principally in utility towers 30 to 100 feet high. Fifty-two percent of nesting pairs observed in 1978 nested on transmission towers.

146. **\*\*Flegg, J.J.M. and C.J. Cox. 1975. Mortality in the black-headed gull. British Birds 68(11):437-449.**

During four periods between 1908 and 1972, the percentage of ringed gulls recovered "dead under wires" varied from 2.1 (1908-1924) to 3.9 (1953-1968) (percentage of total recovery). Of birds banded as nestlings in Britain and Ireland during 1967-1974, 5.7 percent of the juveniles (6 months old and less) and 4.5 percent of the adults recovered were killed striking wires.

147. **\*\*Flegg, J.J.M. and R.A. Morgan. 1976. Mortality in British gulls. Ringing and Migration 1(2):65-74.**

The recoveries of six species of gull banded as nestlings in Britain and Ireland during 1967-1973 are analyzed. The category "found dead" accounted for about 70 percent of the total recoveries. Collision with overhead wires was responsible for appreciable losses among all species except the common gull which suffered considerable mortality due to vehicle collision.

148. **Fredrickson, L.H. 1983. Bird response to transmission lines at a Mississippi river crossing. Transactions of the Missouri Academy of Science 17:129-140.**

Bird response to a 138-kV power transmission facility was monitored near Wittenberg, Missouri, from October to May, 1973 to 1975. Of 132,911 birds flying past the facility, no dead or injured birds were collected nor were any collisions recorded. Only six birds flew close enough to the wires to have their movement classed as near collision; 65 percent of the birds flew at a distance greater than 15 m from the wires. Blackbirds were the most common bird during the study. "The residency status of birds, visibility, disturbance, and habitat are suggested as important factors that may be related to injury or collision."

149. **\*Ganier, A.F. 1962. Bird casualties at a Nashville TV tower. *Migrant* 33(4):58-60.**

Three incidents at the 1,369-foot WSM-TV tower in Nashville, Tennessee, in fall 1962 resulted in losses of 301 birds (39 species) and 2 red bats. Weather data are included.

150. **Garzon, J. 1977. Birds of prey in Spain: the present situation. Pages 159-170 in: R.D. Chancellor, ed. *Proceedings of World Conference on Birds of Prey, International Council for Bird Preservation, Vienna, Austria, 1-3 October 1975.***

The greatest threat to birds of prey in Spain is from overhead cables.

151. **Gauthreaux, S.A., Jr. 1985. Radar, electro-optical, and visual methods of studying bird flight near transmission lines. Prepared by Clemson University, Clemson, South Carolina. Prepared for Electric Power Research Institute, Palo Alto, California. EPRI EA-4120. 76 pp.**

Current and future energy projections to fulfill growing demand indicate that there will be an increase in the miles of power lines erected in the United States. There is concern about the extent of the environmental impact of new lines on avian wildlife, particularly in the area of bird flight behavior and collision mortality. "A lack of data and the abundance of speculation on the impact of transmission lines has resulted in costly delays, route changes, and refusal of permits for line construction projects." The purpose of this study is to provide information on the accuracy and usefulness of equipment (radar and electro-optical instruments) in assessing bird flight behavior and collision rates near transmission lines. Visual methods are also considered as possible study strategies.

152. **\*George, W. 1963. Columbia tower fatalities. *Bluebird* 30(4):5.**

On the nights of 20 and 21 September 1963, 941 birds (46 species) were killed at the KOMU-TV tower, Columbia, Missouri. A species list is given.

153. **\*Gerstenberg, R.H. 1972. A study of shorebirds (*Charadrii*) in Humboldt Bay, California, 1968 to 1969. Thesis. California State University, Humboldt. 207 pp.**

More than 150 northern phalaropes were killed on 6 May 1969 by striking electric wires along the coast near Trinidad, California. Similar incidents, involving fewer birds, occurred on 6 May 1967 and 7 May 1971.

154. **Gillard, R. 1977. Unnecessary electrocution of owls. *Blue Jay* 35(4):259.**

The author reports two great horned owl electrocution mortalities found at the same utility pole in Canada, one in August 1972 and the other in July 1975. Another study is referenced where 13 electrocuted great horned owls were reported. The author recommends that the Saskatchewan Power Corporation follow the U.S. example of pole modifications to reduce the numbers of avian deaths and power outages.

155. Gilmer, D.S. and J.M. Wiehe. 1977. Nesting by ferruginous hawks and other raptors on high voltage powerline towers. *Prairie Naturalist* (March):1-10.

Aerial searches for raptor nests were conducted in spring 1976 along U.S. Bureau of Reclamation 230-kV towers in North Dakota. Ferruginous hawks (21 total, twelve successful nests), red-tailed hawks (five total, three successful nests), and great horned owls (three total, two successful nests) were observed. Most ferruginous hawk nests were constructed in the center of the tower where horizontal steel support members crossed at right angles; most red-tailed hawk nests were constructed near the tops of towers. Several nests were blown out of structures by the wind.

156. Glue, D.E. 1971. Ringing recovery circumstances of small birds of prey. *Bird Study* 18(3):137-146.

This study presents findings on analysis "of recovery details of those five British birds of prey ringed in greatest numbers" - kestrel, tawny owl, little owl, barn owl, and sparrowhawk. Kestrels were more prone to collisions with overhead wires, cables, and buildings than were barn, tawny, and little owls. There was a 3.3 percent mortality rate of band recoveries of the five species from telephone wire or cable collision. A higher percentage of collisions occurred in diurnal species such as kestrels due to hunting methods.

157. \*Gollop, M.A. 1965. Bird migration collision casualties at Saskatoon. *Blue Jay* 23(1):15-17.

During 1961-64, at Saskatoon, Saskatchewan, Canada, 543 dead birds and one red bat were collected at several towers, and 15 dead birds were collected beneath power lines. Species lists are provided.

158. Goodland, R. 1973. Ecological perspectives of power transmission. Pages 1-35 in: R. Goodland, ed. *Proceedings of Biotic Management along Power Transmission Rights-of-Way colloquium, American Institute of Biological Science annual meeting, Amherst, Massachusetts, 21 June 1973. Prepared by The Cary Arboretum of the New York Botanical Gardens, Millbrook, New York.*

Goodland discusses the magnitude of the problem of ecological effects of power transmission, advance regional planning, and tower sitings. He emphasizes that "wetland crossings, streams, and waterings merit special care because they are fragile ecosystems in which apparently minor damage may cause major effects."

159. Goodland Daily News. Nov. 5, 1965. Rare whooping crane is found dead near Atwood. *Goodland Daily News, Kansas* 33(234):1.

A 15-pound whooping crane with a seven-foot wingspan was found dead in a wheat field near Atwood, Kansas. "The only mark on the bird ... was an abrasion on one leg. Death probably resulted from a broken neck when it struck the power line."

- 160. \*Goodpasture, K.A. 1974a. Fall 1972 television tower casualties in Nashville. Migrant 45(2):29-31.**

At the WSM and WSIX towers in Nashville, Tennessee, 556 dead birds (58 species) were collected in fall 1972, the lowest fall total since 1967. The kills were associated with low ceilings and the passage of cold fronts. On 18 October, 141 birds were found dead at the WSM tower, but none were recorded at WSIX on that date. Complete species lists are given.

- 161. \*Goodpasture, K.A. 1974b. Fall 1973 television tower casualties in Nashville. Migrant 45(3):57-59.**

Almost daily checks of the WSM and WSIX towers in Nashville, Tennessee, in September and October 1973 resulted in 165 dead birds found (42 species), the lowest seasonal total since regular monitoring began. Weather was generally mild throughout the fall. Following a clear night, 49 dead birds were collected on 6 October. The WSM tower had recently been painted bright orange and the guy wires were painted with aluminum paint, but it is doubtful if this had any effect on the kill. Lists of the losses are given.

- 162. \*Goodpasture, K.A. 1975. Nashville tower casualties, 1974. Migrant 46(3):49-51.**

A new low (123 birds, 34 species) in fall casualties was recorded at the WSM and WNGE (formerly WSIX) towers in Nashville, Tennessee. As in fall 1973, the weather was "without notable nocturnal violence or stormy force." No clear explanation of the low kills in 1973 and 1974 was obvious, but increased scavenger activity may have been partly responsible. A kill of about 700 birds on 15 September was reported at a tower in Decatur, Alabama. Lists of the Nashville kills are given.

- 163. \*Goodpasture, K.A. 1976. Nashville television tower casualties, 1975. Migrant 47(1):8-10.**

Casualties numbered 513 (53 species) at the WSM and WNGE towers in Nashville, Tennessee, in fall 1975. The weather was generally mild, with fronts of low intensity. Warblers (22 species) accounted for two-thirds of the losses. Cats were noticeable scavengers. A complete kill list is given.

- 164. Goodpasture, K.A. 1978. Television tower casualties, 1976. Migrant 49(3):53-54.**

In September and October 1976, 406 dead birds (43 species) were collected at two towers in Nashville, Tennessee. Ovenbirds had the highest count (63), followed by magnolia and bay-breasted warblers.

165. **\*Goodwin, C.E. 1975. The winter season: Ontario region. American Birds 29(1):48-57.**

During fall 1974, kills at the Lennox power plant chimney and the Barrie and London TV towers in Ontario, Canada, totalled 7,550 birds. Red-eyed vireos (1129), ovenbirds (1038), and magnolia warblers (920) were the species most commonly killed.

166. **\*Goodwin, C.E. and R.C. Rosche. 1971. The fall migration: Ontario. American Birds 25(1):49-54.**

On the night of 13 September 1970, "extensive casualties" (mostly ovenbirds and other warblers) were recorded at London, Ontario, TV towers, and 136 birds were killed at the 1,000-foot Toronto-Dominion Centre.

167. **Goodwin, J.G., Jr. 1975. Big game movement near a 500-kV transmission line in northern Idaho. Prepared for Bonneville Power Administration, Engineering and Construction Division, Portland, Oregon. 56 pp.**

The potential for bird electrocution at a transmission line in Idaho is discussed. While electrocution of large raptors is a problem on low voltage lines (below 115 kV) due to the close spacing of conductors, wider conductor spacing on high voltage lines (such as this 500-kV transmission line in northern Idaho) "corrects this problem." Towers supporting these lines may be beneficial as nesting sites. Although birds observed flying near the conductors on a 500-kV line encountered no problems, the author observed a near collision between a Canada goose and the ground wire running above the conductors.

168. **Gosselin, M. 1978. The winter season: Quebec region. American Birds 32(3):324-326.**

On December 3, 1977, a lesser black-backed gull was found dead below power lines in Quebec, Canada.

169. **Goult, C.A. 1988. Birds and power lines: a bibliography. Council of Planning Librarians Bibliography No. 219. Chicago, Illinois. 11 pp.**

This bibliography contains 143 international listings on birds and utility lines and was prepared specifically "as a reference work for transmission route planning engineers[,] operation and maintenance engineers of electric utilities, ornithologists, and all those concerned and interested in the routing of power lines."

170. **Graber, R.R. 1968. Nocturnal migration in Illinois: different points of view. Wilson Bulletin 80(1):36-71.**

This is an extensive analysis of nocturnal migration using radar, aural recordings, field observations, and tower kills. The kills occurred near Champaign, Illinois, in late

September from 1957 to 1962 and totalled 1,500 birds (41 species). Complete lists of kills are given, and the nature of bird mortality at towers is discussed.

171. **\*Graham, R. 1916. Carolina rail accidentally killed. Oologist 33(11):187.**

A sora was found dead in Ft. Worth, Texas, evidently killed by striking a telephone wire.

172. **\*Green, J.C. 1963. Destruction of birdlife in Minnesota - Sept. 1963. Notes on kills at Duluth on September 18/19. Flicker 35(4):112-113.**

At the Duluth, Minnesota, ceilometer, 92 birds (17 species) were killed. The light was turned off to prevent further losses. Casualties totalled 35 (12 species) at the WDSM tower.

173. **\*Green, J.C. 1964. Fall migration: western Great Lakes region. Audubon Field Notes 18(1):33-34, 39-42.**

During 18-20 September 1963, extraordinary numbers of migrating birds passed through the Minnesota-Wisconsin area. At an Eau Claire, Wisconsin, tower, over 10,000 birds (45 species) were collected; total mortality was estimated at over 30,000. At Ostrander, Minnesota, an estimated 1,500 birds died based on 250 actually collected. In Lewisville, Minnesota, 924 birds (47 species) were collected, and about 100 more were killed at a ceilometer in Duluth. A slow-moving cold front with overcast skies was associated with these incidents.

174. **\*Gregory, H. 1975. Unusual fall tower kill. Bluebird 42(4):9-10.**

On the night of 14 October 1975, over 98 birds (20 species) were killed at four towers in Missouri and Kansas. The KCMO tower in Kansas City, Missouri, accounted for 67 casualties including 32 mourning doves. The incidents were unusual because KCMO is free-standing (*i.e.*, no guy wires) and the cloud ceiling was rather high (5,000-10,000 feet). A listing of casualties by tower is given.

175. **Gretz, D.I. 1981. Power line entanglement hazard to raptors. U.S. Fish and Wildlife Service, Denver, Colorado. 9 pp.**

In Colorado, a ferruginous hawk and a golden eagle were evidently killed by electrocution after their talons became entangled in some loosely wrapped wires holding a power line to an insulator. The author felt that power line entanglement could be a significant mortality factor for raptors. Entanglement problems could be corrected by tightly rewrapping the wire holding the power line to the insulator and installing a cover (split plastic tube) over the wrapping on each side of the insulator.

176. \*Griepentrog, E.A. 1929. Wire mortalities. *Oologist* 46(2):24.

In Oregon during 1926-28, the author noted several instances of bird collisions with telephone wires and barbed-wire fences. Species that struck telephone wires included common snipe, western gull, and mourning dove, while a gray partridge and an American robin struck barbed-wire fences.

177. Grosse, H. and W. Sykora. 1980. Eine 220-kV-Hochspannungstrasse im Überspannungsgebiet der Talsperre Windischleuba war Vogelfalle. *Falke* 27(6):247-248. (In German; not translated.)

178. Haas, D. 1980. Endangerment of our large birds by electrocution: a documentation. *Okol. Vogel (Ecology of Birds)* 2:7-57.

Between 1934 and 1980, the population of white storks in Germany decreased by 78.5 percent. More storks died from overhead lines than from any other cause. The number of mortalities increased over the years: 1937 to 1967, 251 victims; 1971-1979, 335 victims. Analysis indicated that 84 percent of the accidents were caused by ground leakage on the pylons and 16 percent by collision against power lines and/or arcing contact.

179. \*Hall, G.A. 1966. Fall migration: Appalachian region. *Audubon Field Notes* 20(1):41-45.

Several incidents were reported in fall 1965. A TV tower near Charleston, West Virginia, "produced a steady number of dead birds." On the foggy night of 24 September, "over a truckload" were killed at a microwave relay tower and a gasoline compressor station atop a mountain near Buckhannon, West Virginia. On 1 October, over 1,800 dead birds were found at a ski resort near Gatlinburg, Tennessee.

180. \*Hall, G.A. 1968. Fall migration: Appalachian region. *Audubon Field Notes* 22(1):37-40.

On 7 October 1967, 380 birds (42 species) were killed at a tower atop a ridge near St. Alban's, West Virginia.

181. \*Hall, G.A. 1975. The fall migration: Appalachian region. *American Birds* 29(1):57-61.

In fall 1974, tower kills were reported from Knoxville, Tennessee (no data), and Youngstown, Ohio (268 birds).

182. \*Hall, G.A. 1976. The fall migration: Appalachian region. *American Birds* 30(1):67-71.

In fall 1975, 1,031 dead birds were collected at a Youngstown, Ohio, TV tower and 364 were found at a Pittsburgh, Pennsylvania, tower. Near Morgantown, West Virginia, a

small kill occurred at a mountaintop fire tower. There was partial correspondence between the tower kills and other migration indicators, such as banding results.

183. \*Hall, G.A. 1977. The autumn migration: Appalachian region. *American Birds* 31(2):176-179.

About 200 birds died at the Youngstown, Ohio, tower in fall 1976, and a kill was reported (no data) at a Morgantown, West Virginia, fire tower on 3 October.

184. Hallinan, T. 1922. Bird interference on high tension electric transmission lines. *Auk* 39:573.

A turkey vulture, Florida crow, and loggerhead shrike were electrocuted while resting on insulators and metal crossarms of transmission lines in South Jacksonville, Florida, causing flashovers.

185. Hamerstrom, F.N., Jr., B.E. Harrell, and R.R. Olendorff, eds. 1974. Management of raptors -- proceedings of the conference on raptor conservation techniques, Fort Collins, Colorado, 22-24 March 1973. Part 4. Raptor Research Foundation, Inc., Raptor Research Report No. 2.

Excerpts from these raptor conference proceedings include comments on electrocution risk and the use of internal fuses on power poles to decrease power outages. Electrocution risk can increase following a heavy wet snowstorm due to the grounding of poles and wires. Raptor concentration in certain hunting areas may increase after a snowstorm, further increasing the risk of electrocution. It is recommended that utilities determine the high problem areas and concentrate on remedies for those poles.

186. \*Hannum, G., W. Anderson, and M. Nelson. 1974. Power lines and birds of prey. Paper presented at Northwest Electric Light and Power Association. *Wilson Bulletin* 85(4):478.

The Idaho Power Company's program to reduce power line electrocutions of birds of prey is presented, including sketches of design changes for safer poles and conductors.

187. Harris, R.D. 1988. Memo to R. Jurek of California Department of Fish and Game: report of a Golden Eagle mortality. LSA, Pt. Richmond, California. 2 pp.

This memo reports a golden eagle death by power line.

188. Harrison, J. 1963. Heavy mortality of mute swans from electrocution. *Wildfowl Trust* 14th Annual Report:164-165.

During a two-month period in spring 1962, 30 percent of local swan flocks (21 birds) in Romney Marsh, Kent, England, were killed along 1/4 mile of power lines 30 feet high. No distinction is made between deaths by electrocution or collision. The lines cross between feeding and roosting habitat.



189. **\*Harwin, R.M. 1971. White stork: longevity record. Ostrich 42(1):81.**

In Rhodesia, a white stork struck a power line and died in November 1969, 17 years after it had been banded as a nestling.

190. **\*Hatch, D.R.M. 1966. Fall migration: northern Great Plains region. Audubon Field Notes 20(1):61-64.**

Mention is made of "large kills" of warblers, thrushes, and sparrows at TV towers in Winnipeg, Manitoba, Canada, in late September 1965.

191. **Haussler, R.B. 1988. Avian mortality at wind turbine facilities in California. California Energy Commission, Sacramento. 7 pp.**

Data obtained by the California Energy Commission indicates that bird collisions and electrocutions are occurring at wind turbine facilities in California. Most documented incidents are due to collision and are from the Altamont Pass area in Alameda County. "Because there is concern over stability of raptor populations, ways to avoid and reduce losses must be incorporated into [hu]man's development activities....Each wind resource area should be considered specifically to determine (1) the significance of ongoing effects, (2) potential for adverse effects due to future development, and (3) the potential to mitigate and/or avoid adverse effects upon avian populations in the future."

192. **Heijnis, R. 1976. Ornithological mortality and environmental aspects of aboveground high tension lines. Biological Environmental Research, the Netherlands. 166 pp.**

Heijnis remarks that the number of bird deaths from power lines is not excessive but could be significant. Birds living under marginal conditions, due to continual pressures from a number of unfavorable factors could, from a population-dynamic standpoint, be threatened by high tension lines. The author recommends incorporating underground wiring into structural projects or placing all wires at one horizontal level with various marker attachments.

193. **Heijnis, R. 1980. Bird mortality from collision with conductors for maximum tension. Okol. Vogel (Ecology of Birds) 2, Sonderheft 1980:111-129. (English summary.)**

The study site in Holland is located at the Nature Reserves Westzijderveld and de Reef, a wetland area with a high density of wading birds and waterfowl. Collisions occurred more often under conditions of panic-caused flight, changing visibility of the wires, and windy and rainy weather. Most victims were found at night (33 percent) and at dawn and twilight (23 and 29 percent, respectively). Estimated calculations for the study area show 4,000 wire victims per year per kilometer (150- and 380-kV conductors). The author found that the use of strips and plastic spirals to increase wire visibility brought

little or no results; however, silhouettes of raptors made from plastic which were visible in poor light proved to be successful in deterring birds from lines.

194. \*Hendrickson, J.R. 1949. A hummingbird casualty. *Condor* 51:103.

During an aerial display, a male Allen's hummingbird struck a telephone wire and was killed in California.

195. \*\*Herbert, A.D. 1970. Spatial disorientation in birds. *Wilson Bulletin* 82(4):400-419.

The author proposes that bird collisions with human-made lighted structures occur when the birds become spatially disoriented within a bright light because of the loss of true visual cues to the horizontal. The light source may be either a direct beam, such as an airport ceilometer, or the refracted and reflected light from the aircraft warning lights on tall towers during rainy, misty weather. The author illustrates his theory using the case of 58 blackburnian warblers that were killed flying into brightly lit buildings at a Royal Canadian Air Force Base in September 1961 and published accounts by various authors in the literature.

196. \*Herndon, L.R. 1973. Bird kill on Holston Mountain. *Migrant* 44(1):1-4.

At two installations near Elizabethton, Tennessee, 1,801 birds (44 species) were killed by colliding with floodlit buildings and two small (125 and 85 feet) towers. The weather was foggy with northwesterly winds on 30 September and 1 October 1972 when the losses occurred. A kill list is given.

197. \*Herren, H. 1969. The status of the peregrine falcon in Switzerland. Pages 231-238 in: J. Hickey. *Peregrine falcon populations: their biology and decline.* University of Wisconsin Press, Madison, Wisconsin.

Of 14 dead peregrine falcons examined between 1952 and 1965, five had collided with wires. Overhead wires are the main cause of eagle owl fatalities and have contributed to the extermination of the species in much of its former range in Switzerland.

198. \*Heye, P.L. 1963. Tower fatalities. *Bluebird* 30(1):7.

Over 300 birds (47 species) are listed from the kill at the KFVS-TV tower in Cape Girardeau, Missouri, during fall 1962.199. \*Hiltunen, E. 1953. On electric and telephone wire accidents in birds. *Suomen Riista* 8:70-76, 222-223. (In Finnish; English summary.) Capercallie, black grouse, and other game birds were killed in wire collisions primarily in the fall when fog and rain were frequent. Of 225 observed strikes, 76.8 percent were fatal. Over 76 percent of the accidents occurred at twilight.

200. **Hobbs, J.C.A. and J.A. Ledger. 1986. Powerlines, birdlife and the golden mean. Fauna and Flora 44:23-27.**

The authors discuss the "golden mean" of the South African government's 1980 national policy for environmental conservation, which couples development and conservation, and the conflict of overhead power lines and bird species' welfare. The Bird Research Committee (BRC) has developed strategies to discourage birds from nesting or sitting on the critical part of the tower and avoiding electrocution and/or power outages. Besides cape vultures, martial eagles, and other raptors, a few waterfowl species are highly susceptible to collisions with conductors and groundwires. (The BRC also developed orange aluminum spheres to serve as groundwire markers.) The authors suspect that most waterfowl collisions occur when bird flight activity is greatest (*e.g.*, migration) and when visibility is poor (dusk, dawn, or inclement weather conditions).

201. **Holberger, R., L. Morrow, S. Lubores, J. Watson, and F. Williams. 1975. Resource and land investigations program: considerations in evaluating utility line proposals. Prepared by Mitre Corporation, Maclean, Virginia. Prepared for U.S. Department of Interior. Contract 08550-CT5-3, Project No. 3500, Dept. W-54.**

Potential electrocution of raptors and other large birds by power lines is mentioned, specifically lines supplying electricity for pumping or compressing gas or oil through pipelines. Because distribution lines have relatively close spacing of conductors and ground wires, they pose more of an electrocution risk than transmission lines. The authors note that "such electrocutions can be...prevented by application of simple measures in engineering lines for distribution of electric power."

202. **Holyoak, D. 1971. Movements and mortality of Corvidae. Bird Study 16:97-106.**

In England, small numbers of corvids were killed by road traffic and by flying into overhead wires. The author notes they probably died "because of inexperience with these hazards."

203. **\*Hoskin, J. 1975. Casualties at the CKVR-TV tower, Barrie. Nature Canada 4(2):39-40.**

During August and September 1974, 4,900 dead birds were collected at the newly constructed, 1,000-foot tower in Ontario, Canada. Large kills occurred in September on the 10th (409 birds), 13th (704), 14th (371), and 21st (1,523). Among the casualties were 1,000 bay-breasted warblers and 900 ovenbirds. Other species with high losses were the northern parula, northern waterthrush, Cape May warbler, and rose-breasted grosbeak.

204. Howard, R.P. and J.F. Gore, eds. 1980. Proceedings of workshop on raptors and energy developments, Boise, Idaho, 25-26 January 1980. Presented by the Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, and the Idaho Power Company. 125 pp.

Eleven papers on raptors and energy developments were presented at the 1980 meeting of the Idaho Chapter of the Wildlife Society. This symposium served "as a midstream review of where we are and what directions we want to explore." Topics covered include nuclear facility impacts, electrocution, raptor use of power poles, raptor protection activities, and positive and negative impacts of power structures. A list of workshop participants is given.

205. Howe, M.A. 1989. Migration of radio-marked whooping cranes from the Aransas-Wood Buffalo population: patterns of habitat use, behavior, and survival. U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland. Technical Report 21. 33 pp.

In fall 1981, 1982, and 1983 and spring 1983 and 1984, the use of migration stopovers by radio-marked whooping cranes between Aransas National Wildlife Refuge, Texas, and central Saskatchewan, Canada, was studied. A juvenile died during migration after colliding with a power line in October 1981 near Glaslyn, Saskatchewan. After completing its first two migrations, a subadult was found dead under telephone lines near Waco, Texas, in October 1982.

206. Howell, J.A. and J.E. DiDonato. 1991. Assessment of avian use and mortality related to wind turbine operations: Altamont Pass, Alameda and Contra Costa Counties. Submitted to U.S. Windpower, Inc., Livermore, California. 72 pp.

From September 1988 to September 1989, 359 wind turbines were sampled for bird mortality, yielding 42 bird recoveries. Site differences were significant: multiple strikes tended to occur at swales (depressions) and hill shoulders where ridge lines had a stairstep effect. Some species, particularly golden eagles, were more susceptible to impacts from wind turbines. The authors express concern that the number of golden eagle mortalities at U.S. Windpower's facility may have a significant impact on local populations. In addition, the authors recommend that hypotheses about the relationship of visibility, topography, and mortality should be tested to evaluate methods to reduce avian mortality in the Altamont Pass, California.

207. Howell, J.A., J. Noone, and C. Wardner. 1991. Visual experiment to reduce avian mortality related to wind turbine operations: Altamont Pass, Alameda and Contra Costa Counties. Submitted to U.S. Windpower, Inc., Livermore, California. 28 pp.

Three hypotheses about bird collision and wind turbines in the Altamont Pass were tested from August 1988 to August 1989: birds can not see the blades under specific conditions, collisions tend to occur at ends of turbine strings, and collisions tend to occur at swales or hill shoulders. During the study, ten dead birds were found beneath turbines. Increasing turbine blade visibility appeared to reduce the number of collisions.

It was not clearly determined that specific locations are foci for mortality, although site-specific variation did exist. "Additional trials with more sample plots, different painting patterns, and colors will confirm or deny these results."

- 208. Huckabee, J.W. 1980. Effects of power lines and poles on birds. R & D Status Report, Energy Analysis and Environment Division. EPRI Journal (March):49-50.**

This report notes that certain utility poles are preferred by eagles and therefore pose greater risk than poles never used as roosting sites. The author recommends that "preferred" poles be determined by analysis of surrounding vegetation as prey habitat and that these poles be corrected. There is a need for data on collision mortality, changes in behavior from the presence of lines, electromagnetic fields, audible noise, and visual coronas. This report outlines two future projects to study these effects on avian populations.

- 209. Icanberry, J. 1991. Reducing bird-power line collisions. Pacific Gas and Electric, R & D Program Research Results (August). San Ramon, California. 2 pp.**

Researchers developed a prototype collision detection system to measure power line vibrations and distinguish bird collisions from other causes of power line movement. "The new system will allow PG&E for the first time to accurately quantify the impact of existing and proposed overhead wires on bird populations, and to develop suitable collision mitigation measures." The system is available for use on energized power lines maintaining an average load of 15 amperes.

- 210. James, B.W. and B.A. Haak. 1979. Factors affecting avian flight behavior and collision mortality at transmission lines. Final report. Bonneville Power Administration, Portland, Oregon. 106 pp.**

Flight intensity and mortality were highest in fall. Birds flushed from near the lines appeared more susceptible to collision than those routinely crossing the lines. Special attention was focused on flight reactions during inclement weather, specifically fog. Collisions were observed under a variety of environmental conditions, including clear weather, and during both day and night. No definitive relationship was found between inclement weather and increased collision mortality. Fast flying birds in tight flocks at low altitude were most susceptible to collisions. The majority of collisions (83 percent) were the result of birds striking groundwires. "Avian collision mortality from transmission lines in this study was biologically insignificant. However, bird flight altitudes were altered in the vicinity of the lines. Birds flew higher over line structures thus adversely affecting hunting potential in the immediate vicinity of the line (0.5 km)."

- 211. \*James, D. and H.H. Shugart, Jr. 1967. Fall migration: central southern region. Audubon Field Notes 21(1):45-47.**

The comparatively low kill at the Nashville, Tennessee, towers in fall 1966 was attributed to mild weather.

212. **\*James, P. 1956. Destruction of warblers on Padre Island, Texas, in May 1951. Wilson Bulletin 68(3):224-227.**

Following the rainy, stormy night of 5 May 1951, 2,421 dead birds (39 species, mostly warblers) were collected beneath light poles on this coastal island.

213. **\*Janssen, R.B. 1963a. Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at the Lewisville television tower. Flicker 35(4):110-111.**

On the nights of 18 and 19 September, 924 birds (47 species) were killed at the 1,116-foot KEYC-TV tower. The nights were cloudy with drizzle. A list of the casualties is given.

214. **Janssen, R.B. 1963b. Destruction of birdlife in Minnesota - Sept. 1963. Television towers in Minnesota. Flicker 35(4):113-114.**

A list of Minnesota TV towers 500 feet high and over is given. The author notes that these towers are the ones most likely to kill birds. "There are a total of 172 radio and television towers 200 feet in height and over in Minnesota."

215. **\*\*Jaroslow, B. 1979. A review of factors involved in bird-tower kills, and mitigative procedures. Pages 469-473 in: G.A. Swanson, tech. coord. The mitigation symposium: a national workshop on mitigation losses of fish and wildlife habitats. U.S. Forest Service General Technical Report RM-65.**

Estimated losses of between 5 million and 80 million birds annually, due to collisions with human-made structures, are attributed to three major factors: invisibility, deception, and confusion. An overhead wire or other structure becomes "invisible," and hence hazardous, when a bird's attention is directed elsewhere, such as toward the pursuit of prey. Deception is exemplified by birds colliding with windows because the reflected image is perceived as an actual flight path or habitat. Confusion results in large single-night kills at tall, lighted structures when, under overcast conditions, birds are deprived of celestial cues and lose their orientation. Behavioral aspects of the collision problem are discussed in the contexts of various theories of bird navigation on orientation. Mitigative measures include better siting of overhead wires, altering the reflectivity of glass surfaces, eliminating unnecessary structure illumination, and developing an appropriate on-off cycle for warning lights on tall structures.

216. **\*Jarvis, M.J.F. 1974. High tension power lines as a hazard to larger birds. Ostrich 45:262.**

In South Africa, a European stork struck a power line, and 30 cape vultures were electrocuted on a power line over a ten-year period. The vultures perched on pylons and were killed as they wiped their beaks on the wire.

217. **\*Jennings, A.R. 1961. An analysis of 1,000 deaths in wild birds. Bird Study 8(1):25-31.**

In England, traumatic injury (shooting and collisions) accounted for 327 of 1,000 avian deaths analyzed.

218. **\*Johnston, D. 1955. Mass bird mortality in Georgia, October 1954. Oriole 20(2):17-26.**

Details of seven incidents in Georgia during 6-8 October 1954 are presented. The largest kill occurred at the Warner Robins Air Force Base ceilometer near Macon, Georgia, where an estimated 50,000 birds died. A widespread cold front was associated with these incidents.

219. **\*Johnston, D.W. 1957. Bird mortality in Georgia, 1957. Oriole 22(4):33-39.**

Fall bird losses totalling 4,189 (78 species) are listed from several towers, two ceilometers, and one lighthouse in Georgia and South Carolina. Most of the losses occurred on the night of 4 October when rain and cloudy weather prevailed.

220. **Johnston, D.W. and T.P. Haines. 1957. Analysis of mass bird mortality in October, 1954. Auk 74(4):447-458.**

During 5-8 October 1954, coinciding with an advancing cold front, 25 instances of mortality totalling over 100,000 birds (88 species) were reported from ceilometers, towers, and buildings in the eastern U.S. The most commonly killed species were the ovenbird, magnolia warbler, red-eyed vireo, and chestnut-sided warbler. Sex and age composition, weight, fat content, and subspecific composition were analyzed in 2,552 birds killed on 7-8 October at a ceilometer near Macon, Georgia, where an estimated total of 50,000 birds (53 species) died. The massive bird mortalities were primarily associated with nocturnal fall migration.

221. **Judd, P.L. 1910. News notes. Oologist 27(4):51.**

Snipes killed by flying into wires were found on 22 June 1909 near Rathdrum, Indiana.

222. **Jurek, R.M. 1994. Condor information leaflet. California Department of Fish and Game, Sacramento. 4 pp.**

Of eight California condors released into the wild in 1992, three were killed from collision or electrocution at power lines.

223. **Kaiser, G.W. and K. Fry. 1980. Ingestion of lead shot by dunlin. Murrelet 61(1):37.**

At the Fraser River delta of southwestern British Columbia, Canada, 54 dunlin were recorded killed by collision with electrical transmission cables near roosts and feeding areas from 1977 to 1979. Of these, five had pellets of uneroded #4 and #5 shot in their gizzards. "There was no apparent difference between the five birds that contained shot and those that did not."

224. **\*Kale, H.II. 1971. The spring migration: Florida region. American Birds 25(4):723-725, 730-735.**

Bird kills (2,500 birds, 42 species of mostly warblers) are reported from five towers and several buildings on Cape Kennedy in a one-month period.

225. **\*Kale, H.W., II, M.H. Hundley, and J.A. Tucker. 1969. Tower-killed specimens and observations of migrant birds from Grand Bahama Island. Wilson Bulletin 81(3):258-263.**

During the night of 21 October 1966, 136 birds (22 species) were killed at two small towers (200 and 400 ft). About half of the kill consisted of gray-cheeked thrushes and blackpoll warblers. Weather conditions are discussed.

226. **Karlsson, J. 1983a. Faaglar och vindkraft: resultat rapport 1977-1982 (Birds and wind power: result report 1972-1982). U.S. Government Reports 84(23). Available from National Technical Information Service (NTIS) as DE84751012. 12 pp. (In Swedish; English summary.)**

Two large wind generators were erected in Sweden in 1980-82 on arable land and in grazed bushland habitat. Census results did not indicate any effect on bird species diversity or abundance up to 1982. Reactions of migrating birds were to be studied in fall 1983, when the generators would be in continuous operation.

227. **Karlsson, J. 1983b. Faaglar och vindkraft: teknisk rapport 1977-1982 (Birds and wind power: technical report 1972-1982). U.S. Government Reports 84(23). Available from National Technical Information Service (NTIS) as DE84751013. 160 pp. (In Swedish; no translation.)**

228. **\*Kemper, C.A. 1958. Destruction at the TV tower. Passenger Pigeon 20(1):3-9.**

In fall 1957, three large kills, including one estimated at 20,000 birds (based on 1,525 of 40 species collected), were reported from the 1,000-foot Eau Claire, Wisconsin, TV tower. Warblers dominated the kill lists.



229. **\*Kemper, C.A. 1959. More TV tower destruction. Passenger Pigeon 21(4):135-142.**

The tower at Eau Claire, Wisconsin, produced only light kills in 1958 and 300 deaths in spring 1959. Over 2,500 birds (65 species) were killed in fall 1959. The author lists the 1959 kills and discusses weather conditions during the five major kills in 1957 and 1959. He also presents a theory explaining massive tower kills involving the birds's supposed ability to detect geomagnetic lines of force.

230. **\*Kemper, C.A. 1964. A tower for TV: 30,000 dead birds. Audubon Magazine 66(1):86-90.**

An estimated 30,000 birds were killed at the Eau Claire, Wisconsin, tower on the nights of 18 and 19 September 1963. Lists of the 10,195 birds (56 species) actually collected, and of 924 birds (47 species) killed on 20-21 September at Lewisville, Minnesota, are given. To explain the mass mortality of birds at towers, a theory is proposed in which migrants attempt to maintain a constant bearing with respect to the red tower lights (perceiving them as stars) and spiral closer to the structure, eventually striking guy wires.

231. **Kennedy, P.L. 1980. Raptor baseline studies in energy development. Wildlife Society Bulletin 8(2):129-135.**

Accurate assessment of the impacts of energy development on raptor populations in the U.S. are examined, focusing mainly on land disturbance caused by surface coal mining. In order to properly assess the long-term impacts on raptor populations, site-specific studies must be conducted. The author recommends ecological studies on these populations as raptors are good indicator species of total ecosystem health. In addition, since several raptor species are threatened or endangered, industrial impacts may accelerate population decline and ultimately bring about extinction.

232. **Keran, D. 1981. The incidence of man-caused and natural mortalities to raptors. Raptor Research 15(4):108-112.**

This U.S. study summarizes human-caused and natural mortalities to raptors through analysis of personal observations, data on band return frequency, maximum recorded longevity, and average survival for 24 raptor species. No mention of electrocution- or collision-caused mortalities is made other than collision with autos; however, a category called "other" may include these.

233. **Keran, D. 1986. Bald eagle nest on a power pole. Loon 58(3):142.**

This is an account of a bald eagle nest found on an osprey nest site on a power pole near Outing, Minnesota. The nest was sighted on 22 April 1986 and two young eagles were spotted in it two months later.

234. Kibbe, D.P. 1975. The fall migration: western New York and northwestern Pennsylvania. *American Birds* 29(1):53-57.

On the cloudy evening of 21 September 1974, the largest recorded tower kill at the Elmira, New York, TV tower occurred. At least 844 birds (35 species) were killed, bringing the season's total kill at that tower to over 1,200 (44 species).

235. \*Kibbe, D.P. 1976. The fall migration: Niagara-Champlain region. *American Birds* 30(1):64-66.

Over 800 dead birds (40 species) were collected at the Elmira, New York, TV tower on 19 September 1975 following a night of low overcast. Included were 198 bay-breasted warblers, 110 magnolia warblers, and 78 ovenbirds. A kill at an Erie County, New York, tower on 8 September included five pine warblers.

236. Kingery, H.E. 1971. The spring migration: Great Basin-central Rocky Mountain region. *American Birds* 25(4):774-780.

In Wyoming and Colorado, over 78 bald and golden eagles were electrocuted at power lines in spring 1971.

237. Kirtland, K. 1985. Wind implementation monitoring programs: a study of collisions of migrating birds with wind machines. Tierra Madre Consultants. Riverside County Planning Department, Riverside, California. Unpublished report. 12 pp.

Three wind parks in San Geronio Pass, California, were studied to determine the potential for bird collisions. Surveys were conducted 22 April to 14 May 1985 during the spring migration. No dead migratory birds were observed during the surveys; possible reasons include scavenger removal, observer ability, timing of surveys, sample location, sample size/sampling time, and "the strong possibility ... that no birds may be colliding with the machines on the study plots." The results of this study were not extrapolated to other wind parks. It is noted that Southern California Edison conducted a similar study concurrent with this one and found that migratory birds *had* been killed in collisions on a number of wind parks. Recommendations include charging fees to developers to obtain necessary monies for continued monitoring studies.

238. \*Kleen, V.M. and L. Bush. 1973. The fall migration: middlewestern prairie region. *American Birds* 27(1):66-70.

During the night of 1 September 1972, tower kills occurred at Springfield (735 birds, 35 species) and Charleston (137 birds), Illinois.

239. **\*Knauth, O. 1972. Hundreds of birds die after hitting TV tower. Des Moines Sunday Register, 24 September:1, 3.**

On the night of 7 September, 1972, 726 birds, including 406 warblers (22 species), were killed at a 2,000-foot TV tower at Alleman, Iowa. The kill followed the passage of a cold front through the area. A kill of 226 birds (46 species) on 11-12 May is mentioned.

240. **\*Krapu, G.L. 1974. Avian mortality from collisions with overhead wires in North Dakota. Prairie Naturalist 6(1):1-6.**

This is a review of the problem in North Dakota. Personal observations by the author and other experienced field researchers are related, and incidents from the literature are cited. The author notes that the increased construction of power plants and associated transmission lines may pose a significant hazard to birdlife in the state.

241. **Kretzschmar, H. 1969. Grosstrappen fliegen gegen Hochspannungsleitung. Falke 16:94-95. (In German.)**

Several instances of great bustards striking power lines in 1967 and 1968 are reported.

242. **Kretzschmar, H. 1970. Wiederum: Grosstrappe gegen Starkstromleitung. Falke 17:283. (In German.)**

An instance of a great bustard killed by striking a power line in 1969 is reported.

243. **La Berge, W.E. 1976. Waterfowl power line collisions. Illinois Natural History Survey Report No. 160 (October):2-3.**

From September to December in 1973, 1974, and 1975, waterfowl deaths and injuries were monitored at the slag pit of the Lake Sangchris/Kincaid Power plant complex in Illinois. The pit is traversed by two high voltage transmission lines. Of 453 dead birds collected, 353 were known to have died from power line collisions.

244. **\*Lahrman, F.W. 1965. Regina and Lumsden TV tower bird mortalities, 1964. Blue Jay 23(1):18-19.**

In Saskatchewan, Canada, six visits to towers in Lumsden and Regina from 20 August to 4 September resulted in the collection of over 500 dead birds (34 species). Kill lists are given.

245. **\*Lano, A. 1927. Great blue heron (*Ardea herodias*) electrocuted. Auk 44(2):246**

A male great blue heron was found dead beneath power lines in Arkansas on 30 October 1926. Burn marks indicated that it had struck the wires and been electrocuted.

246. **Larkin, R.P. and P.J. Sutherland. 1977. Migrating birds respond to Project Seafarer's electromagnetic field. *Science* 195(2):777-779.**

Radar tracking of individual migrating birds flying over a large alternating current (AC) antenna showed that birds turned or changed altitude more frequently when the antenna system was operating than when it was not. These results suggest that birds sense low-intensity AC electromagnetic fields during nocturnal migratory flight.

247. **\*Laskey, A.R. 1951. Another disaster to migrating birds at the Nashville airport. *Migrant* 22(4):57-60.**

On the night of 7 October, 476 birds of 40 species died at the airport ceilometer in Nashville, Tennessee. The sky was overcast with northerly winds. A kill list is given and the role of winds in the mass mortality is discussed.

248. **\*Laskey, A.R. 1957. Television tower casualties, Nashville. *Migrant* 28(4):54-57.**

Daily searches from 23 September to 15 November, 1957, at a 1,000-foot TV tower in Nashville, Tennessee, resulted in the collection of 704 dead birds (67 species). Cold fronts with overcast skies and north winds accompanied the peak kill dates. A list of the casualties is given. A 878-foot tower with fewer guy wires and an unsupported TV tower produced only a few dead birds.

249. **\*Laskey, A.R. 1960. Bird migration casualties and weather conditions, autumns 1958-1959-1960. *Migrant* 31(4):61-65.**

At Nashville, Tennessee's WSIX tower (940 feet tall), kill totals for the three seasons were 223 (55 species), 562 (59 species), and 1,553 (65 species), respectively. The new 1,369-foot WSM tower, seven miles NNW of WSIX, produced 2,130 casualties (59 species) during fall 1960. Kill lists and descriptions of the towers and weather conditions are given. The ceilometer at the Nashville airport, equipped with a filter permitting only ultraviolet light to pass through, produced no known deaths.

250. **\*Laskey, A.R. 1962. Migration data from television tower casualties at Nashville. *Migrant* 33(1):7-8.**

Daily searches at the WSIX tower in fall 1961 resulted in 228 dead birds (52 species) recovered. One collection at WSM totalled 183 birds (27 species). Kill lists are provided.

251. **\*Laskey, A.R. 1963a. Casualties at WSIX TV tower in autumn, 1962. *Migrant* 34(1):15.**

Daily searches from 6 September to 11 November 1962 yielded 243 dead birds (43 species) at the tower. A species list is given.

252. **\*Laskey, A.R. 1963b. Mortality of night migrants at Nashville TV towers, 1963. Migrant 34(4):65-66.**

On daily visits to three towers in Nashville, Tennessee, in fall 1963, 630 dead birds (62 species) were collected. Two kills occurred on clear nights.

253. **\*Laskey, A.R. 1964. Data from the Nashville TV tower casualties, autumn 1964. Migrant 35(4):95-96.**

Kill totals in fall 1962 at WSM and WSIX were 1,275 (61 species) and 665 (58 species), respectively. The higher total from WSM may be due to its proximity to the city's bright lights and their attractive effect on migrants. Species lists of the kills are provided.

254. **\*Laskey, A.R. 1967. Spring mortality of Blackpoll Warblers at a Nashville TV tower. Migrant 38(2):43.**

Of the 160 birds (12 species) killed at the WSM tower on 14-15 May 1967, 115 (72 percent) were blackpoll warblers, an unusually high number for this species. During the entire spring, 173 birds (13 species) were killed. A list of the casualties is given.

255. **\*Laskey, A.R. 1968. Television tower casualties at Nashville, autumn 1967. Migrant 29(2):25-26.**

The fall kill in 1967 was the lowest to date: 251 birds (40 species) at WSM and 98 (27 species) at WSIX. Lists of the kills are given.

256. **\*Laskey, A.R. 1969a. TV tower casualties at Nashville in autumn 1968. Migrant 40(2):25-27.**

Daily monitoring of WSM from late August through early November 1968 yielded 5,537 dead birds (73 species). Of these, 5,408 were killed on the night of 25 September, 81 percent of which were warblers. The WSIX tower was not checked daily; only 197 dead birds (39 species) were collected there.

257. **\*Laskey, A.R. 1969b. Autumn 1969: TV tower casualties at Nashville. Migrant 40(4):79-80.**

Kill lists are given from WSM (1,602 birds, 57 species) and WSIX (307 birds, 51 species).

258. **\*Laskey, A.R. 1971. TV tower casualties at Nashville: spring and autumn, 1970. Migrant 42(1):15-16.**

Ten birds (nine species) were killed at WSM in the spring. Fall losses totalled 3,683 birds (66 species) at WSM and 104 (21 species) at WSIX. On the drizzly night of 28 September, 3,482 birds (54 species) died at WSM and 78 were killed at WSIX.

Warblers dominated the fall losses: 845 Tennessee warblers, 632 ovenbirds, 429 black-and-white warblers, and 420 magnolia warblers.

259. Lawrence, K.A. and C.L. Strojan. 1980. Environmental effects of small wind energy conversion systems (SWECS). Prepared by the Solar Energy Research Institute (now called National Renewable Energy Laboratory), Golden, Colorado. Prepared for the U.S. Department of Energy. 16 pp.

The authors conclude that the possibility of birds colliding with rotors and towers of Small Wind Energy Conversion Systems (SWECS) is "extremely small" based on the relatively low height of the rotors and towers (an exception might be a very large wind machine sited on a migratory route). Contributing factors noted are solidity of the rotor design; airfoil design; number of organisms flying through the sweep area; behavior of organisms within the sweep area, *e.g.*, flight speed or evasive flight patterns; weather conditions; and total structure height.

260. Laycock, G. 1973. Saving western eagles from traps and zaps: bobcat baits and power poles take heavy toll. *Audubon* 75(5):133.

Electrocution leads to perhaps 300 eagle losses per year (mostly golden eagles). "In Colorado's Moffat County, 37 dead eagles were discovered in a short stretch of 88 utility poles. In Utah, 47 electrocuted eagles were counted beneath 12 miles of power lines. In Texas, six eagles perished on a line bringing electricity to an oilfield." The author states the problem is "preventable"; utility companies say poles can be made safe at a cost of \$135 each.

261. Ledger, J. and J. Hobbs. 1985. First record of African whitebacked vultures nesting on man-made structures. *Bokmakierie* 37(4):99-101.

Six African whitebacked vulture (*Gyps africanus*) nests were found nesting on a 132-kV power line tower structure 14 km from Kimberley, South Africa. The authors cite several contributing factors including increased human disturbances near the vulture's natural habitat and the Electricity Supply Commission's policy of not removing nests unless they pose a direct threat to the electricity supply.

262. Ledger, J., J. Hobbs, and D. van Rensburg. 1987. First record of black eagles nesting on an electricity transmission tower. *African Wildlife* 41(2):60-66.

Young eagles just learning to fly have higher electrocution and power line collision rates than older eagles. Recommendations to reduce such incidents for birds of all ages include (1) locating transformers as far away from towers as feasible and making the underground cable connections as long as possible; (2) building wooden perches over the transformers of preferred towers; (3) covering the exposed wires with insulation or using a completely insulated transformer; and (4) making overhead lines in the vicinity of towers visible with markers. The authors note that bird nests are no longer removed from towers.

263. Ledger, J.A. and H.J. Annegarn. 1981. Electrocution hazards to the cape vulture (*Gyps coprotheres*) in South Africa. *Biological Conservation* 20:15-24.

In this study of vultures' use of power line structures, it was found that 88-kV kite- and H-towers accounted for a "disproportionate" number of electrocutions. The 132-kV lattice steel towers accounted for fewer electrocutions and was a preferred roosting site. The authors recommend further studies to determine preferred tower characteristics for roosting as well as modifying existing towers to increase safety.

264. Lee, J.M., Jr. 1978. Effects of transmission lines on bird flights: studies of Bonneville Power Administration lines. Pages 53-68 in: M.L. Avery, ed. *Impacts of transmission lines on birds in flight: proceedings of a workshop*. Oak Ridge Associated Universities, Oak Ridge, Tennessee. 31 January - 2 February 1978. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-78/48. 151 pp.

Relevant literature and reports on studies and observations of Bonneville Power Administration transmission lines on bird flight behavior and collision mortality are reviewed. Documentation of bird collisions with a 230-kV transmission line at Bybee Lake near Portland, Oregon, is included. Sixty dead birds, mostly waterfowl and gulls, were found from 29 January to 28 April 1977. Reduced visibility was probably a factor. "Experience with BPA transmission lines indicates such lines can affect bird flight and that birds at times collide with conductors or overhead groundwires." Any conclusions about significant avian mortality are "tentative."

265. Lee, J.M., Jr. and D.B. Griffith. 1978. Transmission line audible noise and wildlife. Pages 105-168 in: J.L. Fletcher and R.G. Busnel, eds. *Effects of noise on wildlife*. Academic Press, Inc., New York. 305 pp.

Discussion of transmission line effects on birds and other wildlife includes a 1976 study of the Bonneville Power Administration's 1,100/1,200-kV prototype line near Lyons, Oregon. "Shortly after the first phase of the line was energized an American kestrel (*Falco sparverius*) attempted to land on an energized conductor. The bird approached...within approximately 30 cm of the conductor and after a few attempts at landing it finally flew off. The bird later landed on one of the un-energized phases of the 1,100/1,200-kV line."

266. Lein, M.R. and G.A. Webber. 1979. Habitat selection by wintering snowy owls (*Nyctea scandiaca*). *Canadian Field Naturalist* 93:176-178.

Habitat selection by wintering snowy owls was studied near Calgary, Alberta, Canada, from 1973 to 1976. "Owls tend to use elevated perches such as trees or utility poles early in the morning and toward sunset....It has been suggested that these high perches are hunting perches and that this represents a diurnal pattern of hunting behavior."

267. **\*Lemmon, W.P. 1898. Virginia rail killed by striking a telephone wire. Auk 15(1): 51.**

A Virginia rail collided with a telephone wire in Englewood, New Jersey, on a clear night in 1898.

268. **\*Lewis, J.C. 1974. Ecology of the sandhill crane in the southeastern central flyway. Dissertation. Oklahoma State University, Stillwater. 214 pp.**

Sandhill cranes killed in power line collisions were found at the following sites: Jackson County, Oklahoma (fall 1968); North Platte, Nebraska (25 March 1970); Washita National Wildlife Refuge (March 1974); and Overton, Nebraska (no data given). Reports of power line collisions usually occurred during strong wind storms.

269. **Lister, R. 1965. Fall Migration: Northern Great Plains Region. Audubon Field Notes 19(1):48-53.**

Kills at three towers in Regina, Saskatchewan, Canada, are described. The towers were visited over a two-week period, with a total of 490 mortalities (36 species) recovered.

270. **Lohofener, R. and C.A. Ely. 1978. The nesting birds of LaCreek National Wildlife Refuge. South Dakota Bird Notes (June):24-30.**

A dead burrowing owl was found entangled with a barbed-wire fence.

271. **\*Lupient, M. 1961. Fall migration: western Great Lakes region. Audubon Field Notes 15(1):42-44.**

An estimated 12,000 birds died at towers in the Western Great Lakes region on the night of 21 September 1960. Of these, 1,225 (42 species) were collected at Chippewa Falls, Wisconsin. Other kills in western Wisconsin occurred earlier in the month.

272. **\*Lupient, M. 1962. Fall migration: western Great Lakes region. Audubon Field Notes 16(1):34-35.**

From 2 September to 10 October 1961, 5,097 birds were collected at the Eau Claire, Wisconsin, TV tower. These were estimated to be 10-20 percent of the actual total kill.

273. **Maehr, D.S., A.G. Spratt, and D.K. Voigts. 1983. Bird casualties at a central Florida power plant. Florida Field Naturalist 11:45-68.**

On 23 September 1982, 1,265 birds (30 species from an estimated kill of 3,000) were collected below chimneys at the Crystal River Generating Facility, Citrus County, Florida. The most abundant numbers were white-eyed vireos (49 percent), northern parula (12 percent), red-eyed vireos (9 percent), common yellowthroat (7 percent), and palm warbler (5 percent). On 24 September, an estimated 2,000 birds were involved in chimney collisions. "A fan-shaped distribution of dead birds reflected the prevailing



northerly winds." The authors stress the need to investigate lighting alternatives; lighting appears to attract birds under overcast conditions. Only 5 percent of deaths occurred at shorter chimneys (152 m) painted with alternating red and white bands and with flashing red lights. The taller chimneys were unpainted and had flashing white "strobe" lights.

274. **Malcolm, J.M. 1982. Bird collisions with a power transmission line and their relation to botulism at a Montana wetland. Wildlife Society Bulletin 10:297-304.**

At least 4,100 birds were killed from 1 May 1980 to 27 September 1981 when flying into a 230-kV, double-circuited power transmission line over a large wetland in south central Montana. Contributing factors such as migration, courtship, weather, and visibility are discussed. Carcass tests revealed that the birds were not afflicted by botulism at the time of power line collision, but the carcasses subsequently served as substrate for the botulinus bacteria. The author recommends frequent removal of carcasses to prevent spread of botulism in waterfowl and not installing power lines over large wetland areas.

275. **\*Manuwal, D.D. 1963. TV transmitter kills in South Bend, Indiana, fall 1962. Indiana Audubon Quarterly 41(3):49-53.**

Two towers (1,074 and 650 feet tall) produced 289 casualties (46 species) during fall 1961 and spring and fall 1962. Species lists by tower and other data are given.

276. **Markus, M.B. 1972. Mortality of vultures caused by electrocution. Nature 238:228.**

Power line electrocutions in southwest Transvaal, South Africa, killed at least 148 cape vultures (*Gyps coprotheres*) from 1 January 1970 to 31 March 1972.

277. **\*Marshall, W.H. 1940. An "eagle guard" developed in Idaho. Condor 42:166.**

A device to discourage eagles and other large raptors from landing on power lines was developed by the Idaho Power Company; interruptions of service from short circuits caused by birds (fifty in a winter prior to installation) have been practically eliminated. The project contributed to a saving of bird life as well.

278. **\*Mayfield, H. 1967. Shed few tears. Audubon Magazine 69(3):61-65.**

Bird mortality is discussed in statistical terms. Tower losses may account for one million deaths annually, about 0.016 of 1 percent of the total estimated yearly mortality. Habitat destruction is cited as the main cause for concern for bird populations.

279. **\*McCarthy, T. 1973. Ocular impalement of a great horned owl. Wilson Bulletin 85(4):477-478.**

A great horned owl was found dead in a barbed-wire fence near St. Elizabeth, Missouri, on 24 July 1972.

280. McCrary, M.D., R.L. McKernan, R.E. Landry, W.D. Wagner, and R.W. Schreiber. 1983. Nocturnal avian migration assessment of the San Gorgonio wind resource study area, spring 1982. Prepared for Southern California Edison Company, Research and Development, Rosemead, California. Prepared through the Los Angeles County Natural History Museum Foundation, Section of Ornithology, Los Angeles. 121 pp.

Research was conducted on spring 1982 bird migration in the San Gorgonio Wind Resource Study Area (WRSA) to examine characteristics of nocturnal migration in the area and to assess the potential collision impact on birds. It was determined that the WRSA is heavily utilized by birds as a migratory flyway. "From these studies avian collisions with wind turbines in the WRSA will almost undoubtedly occur." Approximately 182,000 birds per km could potentially come into contact with wind turbine generators each spring in the WRSA. "Although only a small fraction of these birds is likely to collide with wind turbines in the WRSA, even a collision rate of 0.5 percent would yield several thousand deaths per spring season." Recommendations for further study and mitigation measures are included.

281. McDonald, J.N. 1979. Waterfowl collisions with utility wires: two observations on the southern plains. *Texas Journal of Science* 31(4):369-370.

A female shoveler was killed upon colliding with a utility line near Dumas, Texas. A bufflehead was stunned upon collision near Folsom, New Mexico.

282. McGlauchlin, D.C. 1977. Description and chronology of events on Snake Creek embankment. In-house report for the Audubon Wildlife Refuge, Coleharbor, North Dakota. 9 pp.

A roadway area on an embankment separating Garrison Reservoir from Snake Creek, North Dakota, was surveyed for bird carcasses over five summers (1972-1976). Some mortalities were attributed to autos, but many deaths were believed to be caused by collisions with the high voltage power lines.

283. McKenna, M.G. and G.E. Allard. 1976. Avian mortality from wire collisions. *North Dakota Outdoors* 39(5):16-18.

Over a three-month period, 244 dead birds were collected under high voltage transmission lines beside two bodies of water in central North Dakota. Recorded mortality was probably underestimated because unknown numbers of carcasses may have been removed by scavengers or may have fallen in inaccessible places, and crippled birds may have swum away undetected. The American coot (88), double-crested cormorant (52), pied-billed grebe (29), and eared grebe (26) were the most commonly killed species. In addition, 18 ducks of 7 species died. The authors suggest that mortality can be minimized with proper planning and routing of power lines, including burying lines or masking lines by structures such as bridges or trees where the lines cross natural flyways. Other ideas presented were establishing power line corridors through which *all*

lines would be routed and creating such demand that technology would be developed and mitigation costs more acceptable.

- 284. McNeil, R., J.R. Rodriguez, and H. Quellet. 1985. Bird mortality at a power transmission line in northeastern Venezuela. *Biological Conservation* 31:153-165.**

Casualties from distribution line collisions are considered significant. The authors suggest placing lines parallel rather than across flight paths; attempting to make lines more visible by luminous orange markings (wrapped tapes or clipped strips); and burying cables. Species recovered in this study included brown pelican, royal tern, black-crowned night heron, and neotropic cormorant. Data on flight patterns, behavior, feeding, and nesting are included. Frequency of casualties is said to be related to species, composition, behavior patterns, flight characteristics or flight directions, and local features.

- 285. Mead, C.J. 1979. Mortality and causes of death in British sand martins. *Bird Study* 26(2):107-112.**

British band recoveries of dead sand martins (bank swallows) up until 1969 revealed 27 killed by wires and fences.

- 286. Mead, C.J., P.M. North, and B.R. Watmough. 1979. The mortality of British grey herons. *Bird Study* 26(1):13-22.**

One hundred eleven British grey herons were recovered in Britain and Ireland, including eight caught on barbed-wire fencing.

- 287. Medsker, L. 1982. Side effects of renewable energy sources. National Audubon Society, Environmental Policy Research Department Report No. 15. 73 pp.**

"Barriers to wildlife movement" are cited as direct impacts of Wind Energy Conversion Systems (WECS), with the consequence of "possible destruction of birds and insects colliding with wind machines." Choosing sites to avoid migration and flight patterns is recommended.

- 288. Meents, J.K. and M.C. Delesantro. 1979. Use of a 345-kV transmission line by raptors. Prepared for Public Service Company, Albuquerque, New Mexico.**

Raptors tend to utilize tops of utility poles, crossarms, diagonal arms, and static wires.

- 289. Meyer, J.R. 1978. Effects of transmission lines on bird flight behavior and collision mortality. Prepared for Bonneville Power Administration, Engineering and Construction Division, Portland, Oregon. 200 pp.**

In fall 1977 and spring 1978, 31 dead birds (12 species) were found near 5.9 km of transmission lines at seven sites in Oregon and Washington. The lines studied ranged from 115-kV wood pole lines to 500-kV steel tower lines. All sites were in wetland

areas. Ducks represented 35.5 percent of the total mortalities, the majority being green-winged teal. Ninety percent of the deaths occurred at a 250-kV (Lower Crab Creek, Washington) and a 500-kV line (Bybee Lake, Oregon). "Both of these lines contained overhead groundwires which were believed to be largely responsible for the majority of collisions."

290. Meyer, J.R. and J.M. Lee, Jr. 1979. Effects of transmission lines on flight behavior of waterfowl and other birds. Second symposium on environmental concerns in rights-of-way management, University of Michigan, Ann Arbor, 16-18 October 1979.

Study areas were in three locations in western and central Washington and northwest Oregon. Systematic searches in the wetland areas from 1977 to 1978 revealed 31 waterfowl apparently killed from transmission line collisions. All observed bird collisions with 230-kV and 500-kV transmission lines were with small-diameter overhead groundwires. Removing groundwires or increasing their visibility may significantly reduce collision potential.

291. Michener, H. 1928. Where engineer and ornithologist meet: transmission line troubles caused by birds. *Condor* 30(3):169-175.

Flashovers on power lines in the San Joaquin Valley resulted from bird excrement causing arcing between conductors. Large raptors (eagles and hawks) and herons seem to cause the flashovers most frequently, but kestrels were also involved. During the late 1920s technology allowed greater voltages to be transferred through transmission lines, but lines with greater voltages also had more flashovers and longer delays in restoring power to customers. Utility companies were concerned about bird-caused flashovers and developed strategies to prevent birds from roosting on power lines above insulators. The author recommends installing saw-tooth guards between insulators to discourage roosting, inverted "V" grillage of steel straps over center insulators, and steel pans over insulators to prevent excrement from streaming down between them.

292. \*Miller, D., E.L. Boeker, R.S. Thorsell, and R.R. Olendorff. 1975. Suggested practices for raptor protection on powerlines. Edison Electric Institute, Washington, D.C. 21 pp.

Most eagle electrocutions occurred during winter when the birds were more concentrated, and 98 percent of recorded eagle deaths at power lines involved juvenile birds. "The material in this report is an attempt to set forth the state-of-the-art as of June 1975" on modifications to utility poles to reduce electrocution hazards to raptors. Diagrams are included.

293. Miller, M.W. and G.E. Kaufman. 1978. High voltage overhead. *Environment* 20(1):6-36.

Birds' sensitivity to low-frequency electric fields is discussed. Migrating and homing birds are thought to use the earth's magnetic field, among other cues, for their orientation. Electromagnetic field disturbances are thought to disrupt this ability.

294. Minnesota Environmental Quality Board. 1980. Considerations in transmission line routing: biological effects and physical characteristics of fields, ions, and shock. Addendum to the report "Public health and safety effects of high voltage overhead transmission lines." Prepared by Dow Associates, Inc., Berkeley, CA. 151 pp.

An Extremely Low Frequency (ELF) of a test antenna appeared to have a demonstrable effect on flocks of migrants. "Activation of the ELF antenna was clearly associated with a deviation of the average flight direction by 5 to 25 degrees from the control condition." While there was no indication of large-scale migration disturbance, the effects on migration direction were observed even 1 km from the antenna where the emitted frequency was weakest. "Thus birds appear to respond to AC fields of the magnitude and frequency produced by power lines."

295. Moller, N.W. and E. Poulsen. 1984. Vindmoller of fugle (windmills and birds). Vildtbiol. Station, Denmark. From U.S. Govt. Rep. 85(20): 83. (Available from National Technical Information Service as DE85.) 73 pp. (In Danish; English summary.)

In 1983 studies were conducted at Jutland, Denmark, to illustrate any conflicts between wind turbines and birds. There were no birds found killed by wind turbine collision. However, it "cannot be excluded that collisions may occur, *e.g.*, under special weather conditions in connection with illumination of the turbines."

296. Monk, G. 1982. California peregrine falcon reproductive outcome and management effort in 1982. Draft. U.S. Fish and Wildlife Service, Endangered Species Office, Sacramento, California.

Out of 124 nestling peregrine falcons banded, three bands were returned in 1982. Two of those were from birds that had struck power lines.

297. Moorehead, M. and L. Epstein. 1985. Regulation of small scale energy facilities in Oregon: background report. Volume 2. Oregon Department of Energy, Salem.

Examination of the impacts of small energy facility construction includes the potential for birds colliding with towers or lines, leading to injury or death. This can be a significant problem in areas with large bird populations (particularly waterfowl). The following mitigations are recommended: (1) underground lines; (2) flags or marker balls on lines; (3) eliminating small lightning shield wires where lines cross wetlands and migration routes; (4) paralleling lines to prevailing wind directions; (5) constructing lines lower than flight corridors; and (6) placing lines crossing rivers at oblique rather than

right angles. The probability of collision is lowered if trees are close to lines and if the lines are highly visible (larger than 230 kV). To avoid electrocution, proper design and construction techniques can be used such as building nesting platforms. Wind energy facilities are also discussed, as birds can collide with rotating blades or with tower guy wires. Large wetland birds (*e.g.*, geese or cranes) and low-flying migratory songbirds are especially susceptible. Collision potential varies with weather, terrain, turbine placement, rotor design, and rotor speed. The authors suggest that the Oregon Department of Fish and Wildlife ask wind energy applicants to monitor bird kills during operation. Mitigation could include setbacks, height limits, visual clues to alert birds, and choosing sites outside critical areas.

298. **Moretti, P.M. and L.V. Divone. 1986. Modern Windmills. Scientific American (June):110-118.**

Evolution of windmills, windmill structure and components, economic factors, and various design configurations are reviewed. Wind farm development and the future of wind energy are seen as promising means to meet the energy demands of developing countries. Although this article contains no information about avian mortality problems, it offers background information on wind as an energy source and a description of the aerodynamics of wind turbines.

299. **Morgan, R. and D. Glue. 1977. Breeding, mortality and movements of kingfishers. Bird Study 24(1):15-24.**

British kingfisher ringing recoveries from 1910-1974 revealed five individuals (two immatures, three adults) killed by wires.

300. **\*Mosman, D. 1975. Bird casualties at Alleman, Iowa TV tower. Iowa Bird Life 45(3):88-90.**

Casualties at this 2,000-foot tower numbered 1641 (67 species) in fall 1973, 212 (37 species) in spring 1974, and 3,521 (57 species) in fall 1974. The tower was usually checked following overcast nights. However, 496 birds were killed on the night of 13 September 1974 when visibility was excellent. The author estimates 10 percent of the kill was not found due to heavy ground cover. Very few dead birds were found beyond 200 feet from the tower. Complete kill lists for all three seasons are provided.

301. **Mulhern, B.M., W.L. Reichel, L.N. Locke, T.G. Lamont, A. Belisle, E. Cromartie, G.E. Bagley, and R.M. Prouty. 1970. Organochlorine residues and autopsy data from bald eagles. Pesticides Monitoring Journal 4(3):141-144.**

Of 69 bald eagles found dead or moribund in 25 states during 1966-68 (as part of a pesticide residue study), ten were killed due to impact collision; the authors note that most were probably power line kills. Two died from power line electrocution.

302. **\*\*Murarka, I.P., J.G. Ferrante, E.W. Daniels, and E.E. Pentecost. 1976. An evaluation of environmental data relating to selected nuclear power plant sites: Prairie Island nuclear generating plant site. Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, Illinois. ANL/EIS-6. 54 pp.**

Bird losses due to collisions with the 345-kV power line at the Prairie Island plant in Minnesota numbered 40 (22 species), 35 (20 species), and 21 (12 species) on 21 April, 23 May, and 13 September 1974, respectively.

303. **Nelson, M.W. 1982. Human impacts on golden eagles: a positive outlook for the 1980s and 1990s. Raptor Research 16(4):97-103.**

The number of eagle electrocutions in the U.S. can be reduced successfully through cooperative efforts of governmental agencies, conservation organizations, and the electric industry. Transmission line systems sometimes are of a benefit to golden eagles since the steel towers outfitted with nesting platforms can provide good nesting sites.

304. **Nelson, M.W. and P. Nelson. 1976. Power lines and birds of prey. Idaho Wildlife Review (Mar./Apr.):1-7.**

This account describes the results of research begun in 1972 in the U.S. to eliminate the electrocution hazard to large birds of prey, especially eagles. Nationally, it is estimated that 300 to 2,000 eagles are shot or electrocuted at power lines annually. The author used films of a trained eagle to analyze take-off and landing behavior on utility poles. It was found that eagles selectively use certain poles as perches and that 98 percent of electrocuted eagles were inexperienced birds. It was estimated that 95 percent of the electrocutions could be prevented by modifying just 2 percent of the poles. The best modification involved adding a wooden perch three feet above conductors. Safe nesting platforms were developed in cooperation with the Idaho Power Company to be used on poles where eagles habitually build nests, significantly extending nesting habitat in areas where natural nest sites were scarce.

305. **Nelson, M.W. and P. Nelson. 1977. Power lines and birds of prey. Pages 228-242 in: R.D. Chancellor, ed. Proceedings of World Conference on Birds of Prey, International Council for Bird Preservation, Vienna, Austria, 1-3 October 1975.**

The extent of raptor electrocution in the western United States is examined, especially with regard to eagles. The authors describe "economically feasible and practical" solutions, echoing sentiments from their 1976 report (above) that "95 percent of the electrocutions could be prevented by correcting just 2 percent of the poles." Drawings for design corrections, emphasizing safe landing space for the young eagles that comprise 98 percent of electrocution victims, are included.

306. **\*Nero, R.W. 1961. Regina TV tower bird mortalities - 1961. Blue Jay 19(4):160-164.**

At the 670-foot CKCK tower in Saskatchewan, Canada, 94 dead birds (22 species) were found on 3 September 1961, and 113 (20 species) were collected on 10 September. Kill lists and weather conditions are given. The possibility of substantial losses occurring in daylight hours is discussed.

307. **\*Nero, R.W. 1974. Great gray owl impaled on barbed wire. Blue Jay 32(3):178-179.**

In March, near Winnipeg, Manitoba, Canada, a great gray owl became impaled by its wing on a barbed-wire fence and died. Two accounts of great horned owls injured by colliding with barbed wire fences are mentioned. The author remarks that there is a scarcity of records regarding such incidents and that they likely occur more than reported.

308. **\*Nesbitt, S.A. and D.T. Gilbert. 1976. Powerlines and fences: hazards to birds. Florida Naturalist 49(2):23.**

A sandhill crane was killed on a foggy February morning when it collided with a power line near Gainesville, Florida. Such collisions may be a major mortality factor for cranes, herons, waterfowl, and raptors. Careful siting of power lines is important to minimize their impact.

309. **\*Newman, R.J. 1957. The changing seasons. Audubon Field Notes 11(1):4-6.**

Mention is made of 2,500 birds killed at a Chapel Hill, North Carolina, TV tower.

310. **\*Newman, R.J. 1958. The changing seasons. Audubon Field Notes 12(1):4-9.**

Included is a brief general discussion of the tower kill situation in the U.S. and an appeal for more systematic monitoring of towers and reporting of findings.

311. **\*Newman, R.J. 1961. Fall migration: central southern region. Audubon Field Notes 15(1):46-51.**

The total fall 1960 mortality at two Nashville, Tennessee, towers was 3,683 birds (77 species). Only 14 dead birds were collected at the WBRZ tower in Baton Rouge, LA.

312. **\*Newman, R.J. and G.H. Lowery, Jr. 1959. The changing seasons. Audubon Field Notes 13(4):346-352.**

In spring 1959, tower kills were quite light, but bird losses at windows and power lines "attracted notice all over the nation." In Detroit, Michigan, 284 birds were killed at a TV tower.



313. **Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota. 399 pp.**

Nearly one-third of all band recoveries of British sparrowhawks and kestrels during the period 1959-1969 were mortalities caused by collisions with vehicles, buildings, and other structures.

314. **\*Niles, D.M., S.A. Rohwer, J.A. Jackson, and J.D. Robins. 1969. An observation of midwinter nocturnal movement and tower mortality of tree sparrows. Bird-Banding 40(4):322-323.**

In late January 1969, near Lawrence, Kansas, 19 tree sparrows were killed at a 600-foot tower and two died at a 300-foot microwave tower. This is taken as evidence for occasional extensive mass midwinter movements by this species, probably in response to bad weather.

315. **\*Norman, J.L. 1975. Birds killed at a TV tower near Coweta, Oklahoma. Bulletin of the Oklahoma Ornithological Society 8(3):25-27.**

Among the 177 birds (28 species) killed at the KTUL tower on 9 October 1974 were 64 Nashville warblers. Smaller kills (24 birds, 12 species) were recorded in late September. All casualties are listed.

316. **\*Norman, J.L. 1976. Birds killed at a TV tower near Coweta, Oklahoma. Bulletin of the Oklahoma Ornithological Society 9(3):20.**

During 12-15 September 1975, 99 birds (27 species) were collected at the KTUL tower. Casualties are listed by date.

317. **\*Norman, J.L. 1977. Birds killed at a TV tower near Coweta, Oklahoma in the fall of 1976. Bulletin of the Oklahoma Ornithological Society 10(1):6-8.**

During September and October 1976, 166 dead birds (49 species) were collected at the KTUL tower. A list of the casualties by date of collection is given.

318. **\*Norwood, J.R. 1960. TV tower casualties at a Charlotte station. Chat 24(4):103-104.**

In late September and early October 1960, 390 birds (32 species) were found dead at the 1,000-foot WSOC tower in Charlotte, North Carolina. A kill list is given.

319. **NUS Corporation. [1979]. Impacts of overhead wires on birds: a review. Unpublished report. Prepared for the Electric Power Research Institute, Palo Alto, California. 47 pp.**

This report compiled from a variety of sources examines the issue of bird collisions with overhead wires. Factors found to influence the frequency of collisions include poor visibility due to weather or time of day; weather (winds, rain) which causes birds to fly lower than normal; disturbances and distractions (mating, pursuit of prey); cable size (smaller wires cause greater frequency of collisions than larger ones); age (young birds collide more often than adults); and line location (those below tree tops are less hazardous than more exposed lines). Species with long legs and necks collide more often than those with shorter appendages. High wing loading, as in swans, reduces the ability to maneuver around lines. The report recommends that power lines circumvent wetlands to reduce waterfowl casualties.

320. **\*Ogden, J. 1960. Observations at a TV tower during a bird fall. Migrant 31(4):65-67.**

During the night of 28 September, 321 birds (30 species) were killed at the WSM TV tower in Nashville, Tennessee. No chips (number of bird calls in a 60-second interval) were heard when the sky was clear. As clouds gathered, observers counted increasing numbers of chips and birds started falling. The chip count dropped when the sky partially cleared, but birds continued to fall at a steady rate; some were merely injured or stunned.

321. **\*Ogilvie, M.A. 1967. Population changes and mortality of the mute swan in Britain. Wildfowl Trust 18th Annual Report:64-73.**

Of 1,051 mute swans in England whose cause of death was known, 44 percent died from wire collision.

322. **Olendorff, R.R. 1986. Raptor collisions with utility lines and fences: an annotated bibliography (review draft). U.S. Bureau of Land Management, Sacramento, California. 14 pp.**

This draft annotated bibliography contains 14 pages of entries pertaining to avian collision, specifically with respect to raptors.

323. **Olendorff, R.R., D.D. Bibles, M.T. Dean, J.R. Haugh, and M.N. Kochert. 1989. Raptor habitat management under the U.S. Bureau of Land Management multiple-use mandate. Raptor Research Report No. 8. Raptor Research Foundation, Provo, Utah. 80 pp.**

This document was prepared "to refine and expand on the overall goal of the Bureau of Land Management (BLM) in conserving and managing raptors and their habitats on public lands (*i.e.*, those lands administered by BLM)." Included is a section on power line studies and policy. Another study by Olendorff (with Lehman 1986, below) noted

that power line collisions "do not result in a discernable effect on population dynamics of raptors, except in cases involving critically endangered species." A 1980 Pacific Power and Light Company 550-kV transmission line project from southcentral Idaho to central Oregon is cited as setting the precedent as the first implemented and adequately monitored mitigation of its type (including artificial raptor nesting platforms).

324. **Olendorff, R.R. and R.N. Lehman. 1986. Raptor collisions with utility lines: an analysis using subjective field observations, final report. Prepared by U.S. Bureau of Land Management. Prepared for Pacific Gas and Electric Company, San Ramon, California. 73 pp.**

Data were collected internationally on 88 probable raptor collisions with utility lines, including species, age class, type of line, configuration, and injuries. Peregrine falcons, bald eagles, golden eagles, red-tailed hawks, and ospreys were the species most commonly reported. "Though raptor collisions with utility lines will always contribute to proximate mortality of individuals, it does not seem likely that collisions could become an ultimate cause of population declines, except for critically endangered species such as the California condor."

325. **Olendorff, R.R., R.N. Lehman, and P.J. Detrich. 1986. Biological assessment: anticipated impacts of the geothermal public power line on federally listed threatened or endangered species, with emphasis on the bald eagle. U.S. Bureau of Land Management, Sacramento, California. 72 pp.**

Based on a two-year study, this biological assessment examines the proposed Geothermal Public Power Line's (GPPL) impact on endangered species and their habitats, especially the bald eagle. The project includes a 55.7-mile transmission line from the Geysers to Williams, California. The Bureau of Land Management concludes that the project "may affect" an endangered species "because of the possibility of one or more bald eagles in the area colliding with the GPPL..." Impacts to the Pacific northwest eagle population could occur on two levels: "(1) general impacts to raptor populations resulting from power line collisions; and (2) the specific risks to [individual] bald eagles within each proposed GPPL corridor." Mitigation measures are discussed.

326. **Olendorff, R.R., A.D. Miller, and R.N. Lehman. 1981. Suggested practices for raptor protection on power lines: the state-of-the-art in 1981. Prepared by the Raptor Research Foundation, St. Paul, Minnesota. Prepared for the Edison Electric Institute, Washington, D.C. 111 pp.**

This report includes full sections on issue identification and resolution and the biological aspects of raptor electrocution. "Raptors are basically opportunistic and utilize power lines and support structures for a number of purposes, especially perching and nesting. The heaviest use is as hunting perches." Power line designs and modifications for raptor safety include 1) methods to address problems of design and modification of poles, crossarms, and wire placements for adequate separation of energized hardware; 2) insulation of wires and other hardware where sufficient separation cannot be attained; and 3) management of eagle perching. Other mitigation measures are described for power

line construction, maintenance, and operation to address impacts other than electrocution. An annotated bibliography and index are included.

327. Olsen, J. and P. Olsen. 1980. Alleviating the impact of human disturbance on the breeding peregrine falcon II: public and recreational lands. *Corella* 4(3):54-57.

Of 14 peregrine falcons found dead in Switzerland, five had been killed from striking wires. One hunting peregrine falcon was witnessed colliding with a telephone line. Impacts on other species are discussed: overhead wires are believed to be one of the main causes of injuries to merlins in Britain, and five injured Australian hobbies (*Falco longipennis*) appeared to have collided with wires. More research is warranted in Australia regarding avian electrocutions and collisions with overhead wires. The authors recommend that wires and fences be placed far from eyrie and hunting sites. Young falcons are particularly susceptible to wire collision.

328. \*Olsson, V. 1958. Dispersal, migration, longevity, and death causes of *Strix aluco*, *Buteo buteo*, *Ardea cinerea*. *Acta Vertebratica* 1(2):91-189.

Recoveries of birds banded in Sweden, Norway, and Finland showed that "Found dead under power-line" was the cause of death given for 30 of 371 tawny owls, 11 of 473 common buzzards, eight of 979 common herons, and nine of 1,251 herring gulls. In the latter three species, "Shot" was the most common cause of death.

329. O'Neil, T.A. 1988. An analysis of bird electrocution in Montana. *Journal of Raptor Research* 22(1):27-28.

O'Neil analyzed fifty incidents of reported electrocutions involving 61 birds from a five-year period. Golden eagles were the most commonly reported and were involved in 32 cases (54 percent of total). Great horned owls were reported in 12 cases (24 percent of total). Poles along hilly grasslands had twice the potential to kill multiple birds than poles along flat agricultural terrain. Sixty-one percent of electrocutions occurred on poles with either double crossarms or with a transformer present. Mitigative measures initiated by power companies included altering pole configurations: increasing conductor spacing and/or installing elevated raptor perches. "In all cases where mitigative measures have been incorporated there were no reports of further electrocutions."

330. Orloff, S. 1992. Tehachapi wind resource area avian collision baseline study. BioSystems Analysis, Inc., Tiburon, California. 40 pp.

The goal of this study was to evaluate the potential for avian collisions by comparing baseline field data collected at the Tehachapi Wind Resource Area (WRA) to data from BioSystem's Altamont Pass WRA study. Mortality at Tehachapi was significantly lower than at Altamont; no dead or injured birds were found during the Tehachapi surveys. Turbine location, site elevation, and structure density were identified as factors contributing to higher mortality at Altamont. Lower raptor abundance and susceptibility to collision (defined as perching on turbines and flying lower to the ground) were observed in Tehachapi; ground squirrels, a common prey species for raptors, were less

abundant. The risk of avian mortality at Tehachapi may increase in the near future for three reasons: (1) new windfarm development expanding into areas frequented by golden eagles; (2) increase in ground squirrels in the area; and (3) re-introduction of the California condor into its former range, including Tehachapi.

331. Orloff, S. and E. Cheslak. 1987. Avian monitoring study at the proposed Howden windfarm site, Solano County, Phase I: draft report. BioSystems Analysis, Inc., Sausalito, California. J-249. 34 pp.

A proposed wind park would be located in the Benicia Hills, Solano County, California, in close proximity to the Suisun Marsh. Suisun Marsh is an important wetland wintering area for waterfowl along the Pacific Flyway, as well as an important raptor winter-foraging area. Ten avian species with special legal or management status, including bald eagle, peregrine falcon, and golden eagle, occur or may occur at the site. Observation data on bird species, age, sex, flight behavior, and other environmental variables were collected between 27 November 1985 and 14 November 1986. It was concluded "that there is a potential for bird collisions with the proposed wind turbines."

332. Orloff, S. and A. Flannery. 1992. Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County wind resource areas. Prepared by BioSystems Analysis, Inc. Tiburon, California. Prepared for the California Energy Commission, Sacramento. Grant 990-89-003. 150 pp. plus appendices.

Six seasons of field work (1989-1991) in the Altamont Pass, California, were conducted with the purposes of evaluating the extent and significance of the impact of wind turbines on birds, identifying the causes and factors contributing to bird deaths, and recommending mitigation measures. Of 182 dead birds found on the ground near turbine and transmission line structures, 119 (65 percent) were raptors. Fifty-five percent of all raptor deaths were attributed to turbine collisions, 8 percent to electrocution, 11 percent to wire collision, and 26 percent to unknown causes. Recommendations include further studies to investigate factors contributing to mortality and to determine effective modifications to reduce deaths.

333. \*Owen, M. and C.J. Cadbury. 1975. The ecology and mortality of swans at the Ouse Washes, England. *Wildfowl* 26:31-42.

Of 128 swan mortalities where the cause of death was known, 49 (38 percent) were due to collisions with power lines. Three species of swan were studied: Bewick's, Mute, and Whooper.

334. **Pacific Gas and Electric Company. 1984. Solano County MOD-2 wind turbine field experience: interim report. Prepared by PG&E's Department of Engineering Research, San Ramon, California. Prepared for the Electric Power Research Institute, Palo Alto, California. EPRI AP-3896. Project 1996-3. 50 pp. plus appendices.**

The objective of this project was to document and evaluate Pacific Gas and Electric Company's experiences while testing, operating, and maintaining a megawatt-scale wind turbine in Solano County, California. This interim report covers the first year, ending 31 August 1983. Bird mortalities were monitored to measure the wind turbine's impact. A total of seven birds (unlisted) were found, all between mid-summer and mid-fall; collisions occurred during all lighting and weather conditions. Avian mortality was considered "insignificant."

335. **Pacific Gas and Electric Company. 1985. MOD-2 wind turbine field experience in Solano County, California: final report. Prepared by PG&E's Department of Engineering Research, San Ramon, California. Prepared for Electric Power Research Institute, Palo Alto, California. EPRI AP-4239. Project 1996-3. 100 pp. plus appendices.**

This two-year field study of a 2.5-megawatt MOD-2 wind turbine in Solano County, California, was conducted to evaluate performance and environmental impacts, including the effects on bird populations. Avian collision mortality was monitored for one year (September 1982 through August 1983). Seven dead birds were found, five under the wind tower (three passerines, a waterbird, and a raptor) and two beneath the meteorological tower (passerines). Collisions occurred during all lighting and weather conditions. Low rates of waterfowl movement and nocturnal passerine migration were noted over the site, and raptor use of the area was moderate. The report concludes that the impact of the wind tower on birds is "minimal."

336. **\*Pangburn, C. 1945. Extraordinary fatality to a blue-winged teal. Auk 62(1):142.**

A blue-winged teal struck two overhead wires with such force that they were driven into the skull. The incident occurred on 22 March 1944 at San Antonio, Texas.

337. **\*\*Parmalee, P.W. and B.G. Parmalee. 1959. Mortality of birds at a television tower in central Illinois. Bulletin of the Illinois Audubon Society 111:1-4.**

During the foggy, cloudy night of 16 September 1958, at least 827 birds (40 species) were killed at the 1,000-foot WICS-TV tower at Springfield, Illinois. Weather conditions and a kill list are given.

338. **\*Parmalee, P.W. and M.D. Thompson. 1963. A second kill of birds at a television tower in central Illinois. Bulletin of the Illinois Audubon Society 128:13-15.**

At the WICS tower in Springfield, Illinois, 219 birds (31 species) were killed in one night. Weather is discussed in detail and comparisons with an earlier incident are made. A kill list is included.

339. **Perrins, C.M. and C.M. Reynolds. 1967. A preliminary study of the mute swan, *Cygnus olor*. Wildfowl Trust 18th Annual Report:74-84.**

Approximately 58 mute swan deaths from collisions with wires and other objects were recorded by month of death from 1960 to 1966 in and around Oxford, England. The authors noted more deaths in spring and autumn than in summer.

340. **\*Petersen, P.C., Jr. 1959. TV tower mortality in western Illinois. Bulletin of the Illinois Audubon Society 112:14-15.**

Following a foggy, overcast night, 88 dead birds (32 species) were found at the 983-foot WHBF tower near Orion, Illinois.

341. **\*Petersen, P.C., Jr. 1967. Fall migration: middlewestern prairie region. Audubon Field Notes 21(1):44-45.**

At Columbia, Missouri, on 20 September 1966, 618 birds (32 species) were killed at the KOMU tower. In Floyd County, Indiana, on 22-23 September, 123 birds died. At a tower in Dayton, Ohio, 305 birds (49 species, mostly red-eyed vireos, golden-crowned kinglets, and ovenbirds), died during fall 1966.

342. **\*Petersen, P.C., Jr. 1968. Fall migration: middlewestern prairie region. Audubon Field Notes 22(1):48-50.**

At the WHIO tower in Dayton, Ohio, 348 birds (45 species, mostly red-eyed vireos and warblers) were killed from 9 September to 15 November 1967. At a tower in Floyd Knobs, Indiana, over 78 birds (mostly thrushes and warblers) died on 6 and 7 October.

343. **\*Petersen, P.C., Jr. 1971. Fall migration: middlewestern prairie region. American Birds 25(1):64-66.**

At a tower near Springfield, Illinois, 212 birds (28 species) died on 22-23 September 1970, and 37 birds (16 species) were killed on 13-14 October.

344. **\*Peterson, A.W. 1963. Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at Park Rapids. Flicker 35(4):113.**

Following the densely foggy night of 15 September 1963, the main street of Park Rapids, Minnesota, "was littered with dead or dying birds" probably as a result of migrants being attracted to street lights and smashing into buildings.

345. **\*Peterson, R.L. and B.P. Glass. 1946. Notes on bird mortality during nocturnal thunderstorms near College Station, Texas. Condor 48(2):95-96.**

Following several severe storms in spring 1941, dead birds were collected, including 16 snow and blue geese, beneath electrical power lines in Texas.

346. **Phillips, P.D. 1979. NEPA and alternative energy: wind as a case study. Solar Law Reporter 1(1):29-54.**

This article examines the issue of whether and when the National Environmental Policy Act (NEPA) applies to alternative energy sources, using wind as a case study. Potential environmental impacts of wind development are discussed, and construction of a 1.5-megawatt wind turbine is used for illustrative purposes. The hazard of bird collision is noted, especially with regard to migratory birds; "[t]he risk would be small for high flying migratory waterfowl, but would increase for low flying nocturnal migrants, such as many songbirds."

347. **Phillips, R.L. 1986. Current issues concerning the management of golden eagles in western U.S.A. Birds of Prey Bulletin No. 3:149-156.**

An overview of the problems facing golden eagles during the 1980s in the western United States is presented. Eagle mortality records and interviews with raptor biologists suggest that the magnitude of electrocution dropped significantly from 1980 (109 deaths) to only 15 in 1984. The author believes "this drop...is a direct result of cooperative efforts between government, the power industry, and conservation efforts."

348. **\*Pierce, M.E. 1969. Tall television tower and bird migration. South Dakota Bird Notes 21(1):4-5.**

Two sizable kills occurred in 1965 at the 1,117-foot KSOO tower near Flandreau, South Dakota. During the night of 27 March, 578 horned larks died in a sudden snowstorm by colliding with the windows of the transmitter building or with the tower. Early in the morning of 14 September, 102 birds (32 species) were killed, mainly by striking windows on the building. A kill list is given. No other incidents involving more than a few birds occurred from July 1960 to May 1968.

349. **Pogson, T.H. and S.M. Lindstedt. 1988. Abundance, distribution and habitat of Central Valley population greater sandhill cranes during winter. Biology and Wildlife, University of Alaska, Fairbanks.**

Power line collisions seem to be the largest source of unnatural mortality for California's Central Valley sandhill crane population. The authors feel reported results could be slightly skewed towards collisions with power lines due to the bias in finding carcasses.



350. **Pomeroy, D.E. 1978. The biology of Marabou storks in Uganda, II: breeding biology and general review. Ardea 66(1-2):1-23.**

"In Uganda, Marabou storks (*Leptoptilos crumeniferus*) are rarely killed by [hu]man[s] but in some places they fly into overhead power-lines and apparently die from electrocution."

351. **Portland General Electric Company. 1986. Cape Blanco wind farm feasibility study. Technical Report No. 11: Terrestrial ecology. Bonneville Power Administration, Portland, Oregon. DOE/BP-11191-11. 56 pp.**

This report evaluates the potential terrestrial ecology impacts of the construction and operation of a wind energy conversion system located near Cape Blanco in Curry County, Oregon. "All three Cape Blanco wind farm alternatives under consideration pose a potential threat of collisions for birds flying at low altitudes." Nocturnal songbirds are especially expected to be impacted. Guy wires and lighting of the units are identified as probable collision hazards. Potential impacts of support facilities (two transmission line routes to an existing Bonneville Power Administration 230-kV line) are evaluated. "The potential for electrocution of large birds would be small because the lines would be designed with adequate space between conductors to prevent a bird from simultaneously touching two phases. Neither alternative route would be located where bird collisions would be expected." Mitigation measures are discussed, including building the wind farm in increments and monitoring for bird kills after each phase as a condition for building the next.

352. **\*Potter, J.K. and J.J. Murray. 1949. Fall migration: middle Atlantic coast region. Audubon Field Notes 3(1):8-10.**

In a heavy fog on the morning of 11 September 1948, "hundreds and perhaps thousands" of birds, mostly warblers, struck tall buildings and towers in Philadelphia. At Cape May, New Jersey, 50 species were collected at telegraph wires and radio towers in September and October. Two barn owls were among the casualties.

353. **Power Technologies, Inc. 1978. Observations of birds and mammals. Pages 173-177 in: Transmission line reference book, 115 kV-138 kV compact line design. Prepared for the Electric Power Research Institute, Palo Alto, California. Research Project 260.**

This work was based on an EPRI report that examined responses of approaching birds to electrostatic fields caused by lines of variable voltage. It was found that an electrical field from an energized conductor "will cause a current through the bird; and if the field exceeds a perception value, the bird may be frightened away." Small- and medium-sized birds were unconcerned with voltages of 33 kV, somewhat affected by 69 kV lines, and deterred by lines with a voltage of 138 kV or greater.

354. **Prevost, Y.A., R.P. Bancroft, and N.R. Seymour. 1978. Status of the osprey in Antigonish County, Nova Scotia. Canadian Field Naturalist 92:294-297.**

Data were gathered from 1972 to 1976 on osprey nest sites, breeding pairs, and reproductive success in Nova Scotia, Canada. Twenty-two out of 26 nests were located on utility poles along power lines; the double "T" design of the poles seemed to provide excellent nest supports. Power lines seemed to provide the best locations for colonial nesting in northeastern Nova Scotia: "Human encroachment, the widespread practice of beaver-dam removal, and the overcut state of Antigonish County forests have presumably decreased the number of available natural nest sites."

355. **Public Service Company of New Mexico. 1976. PNW raptor study. Albuquerque, New Mexico. Unpublished report. 20 pp.**

Raptor use of transmission lines is monitored in northwest, north-central, south-central, and southwest New Mexico. Nine species have been observed on structures: Cooper's hawk, red-tailed hawk, rough-legged hawk, ferruginous hawk, Swainson's hawk, golden eagle, prairie falcon, peregrine falcon, and American kestrel. An update of raptor use at the Ambrosia Lake-Four Corners 230-kV transmission line from 1973 to 1976 is included. Seven species have been observed to utilize the line: American kestrel, red-tailed hawk, golden eagle, prairie falcon, ferruginous hawk, rough-legged hawk, and peregrine falcon (observed once in 1973). Tops of poles, crossarms, diagonal arms, and static wires were the most frequently used portions of the line. Only kestrels used static wires; buteos and golden eagles were generally seen on tops of poles. X-braces were occasionally used as red-tailed hawk nest sites.

356. **\*Purrington, R.D. 1969. Fall migration: central southern region. Audubon Field Notes 23(1):65-70.**

At the WSM tower in Nashville, Tennessee, 5,408 birds (4,857 warblers) died the night of 25 September 1968. This figure is more than half of the total mortality from Nashville towers and ceilometers in the past 20 years.

357. **\*\*Quigley, E. 1977. Utility line siting and wetlands preservation. Dissertation. University of Wisconsin, Madison. 231 pp.**

Quigley discusses several studies of bird losses at utility lines; one conclusion is that "[u]tility lines can have significant impacts on wetland hydrology and waterfowl."

358. **Quortrup, E.R., and J.E. Shillinger. 1941. 3,000 wild bird autopsies on western lake areas. Journal of the American Veterinary Medical Association 99:382-387.**

Autopsies of 3,000 wild birds from western and northern United States were performed between 1937 and 1940. Botulism was the main cause of death (47.9 percent) and mechanical injury (gunshot, wire strikes, etc.) accounted for 18.5 percent of the deaths analyzed.\*

359. Rees, M.D. 1989. Andean condors released in experiment to aid the California condor. *Endangered Species Technical Bulletin* XIV(1/2):8-9.

Of the Andean condors raised in southern California as part of the California condor propagation effort, one of the juveniles released was found dead directly below a power line. It is believed the bird brushed or collided with the lines during flight and was electrocuted.

360. Reidinger, R.F., Jr. and D.G. Crabtree. 1974. Organochlorine residues in golden eagles, United States: March 1964-July 1971. *Pesticides Monitoring Journal* 8(1):37-43.

This article reports necropsy and residue findings for 169 golden eagles that were dead, dying, or severely incapacitated and sent to Denver Wildlife Research Center between March 1964 and February 1970. Of the eagles found, death by unnatural causes was determined for 63. Deaths due to shooting or contact with power lines were most common. Power line collision and/or electrocution caused 8.9 percent of mortalities.

361. Riegel, M. and W. Winkel. 1971. On death causes of white storks (*C. ciconia*) according to ringing recovery reports. *Vogelwarte* 26(1):128-135. (In German; English summary.)

In Germany, of 294 storks for which the cause of death was known, 226 (77 percent) died from collisions with telegraph wires. Inexperienced birds were more prone to collide with wires than were older birds.

362. \*Rix, C.E. 1970. Birds of the Northern Territory. *South Australian Ornithologist* 25(6):147-191.

In July 1967, near Darwin in southern Australia, five dead jabiru (black-necked storks) were found beneath a power line at Fogg Dam. Fourteen live birds were also present.

363. \*Robbins, S.D. 1967. Fall migration: western Great Lakes region. *Audubon Field Notes* 21(1):36-38, 42-44.

On 14 September 1966, 2,117 birds (37 species) died at a tower in Eau Claire, Wisconsin. Similarities were noted between the most abundant species in the kill and those recorded in the field. Robbins discusses the difficulty in judging migration by just one method.

364. \*Robbins, S.D. 1969. Fall migration: western Great Lakes region. *Audubon Field Notes* 23(1):55-56, 64.

A kill of over 2,000 birds occurred at the WEAU tower in Eau Claire, Wisconsin, on 19-20 September 1968; 145 birds died on 18-19 October, two weeks later than any previous kill at this site. The October kill was composed chiefly of kinglets and late migrant warblers.

365. **\*Robertson, W.B., Jr and J.C. Ogden. 1969. Fall migration: Florida region. Audubon Field Notes 23(1):35-40.**

In fall 1968, 853 birds (80 species) died at the WCTV tower, Tallahassee, Florida.

366. **Rogers, S.E., B.W. Cornaby, C.W. Rodman, P.R. Sticksel, and D.A. Tolle. 1977. Environmental studies related to the operation of wind energy conversion systems: final report. Prepared by Battelle's Columbus Laboratories. Prepared for the U.S. Department of Energy, Division of Solar Technology, Wind Systems Branch. USDE/W-7405-ENG-92. 108 pp. plus appendices.**

The environmental consequences of emerging wind energy conversion technology are assessed. Field studies were done at the DOE/NASA 100-kW Experimental Wind Turbine located at Lewis Research Center's Plum Brook Station near Sandusky, Ohio. During four migratory seasons of searching (spring and fall 1975, fall 1976 and spring 1977), two birds were found dead near the meteorological tower and one was found near the turbine. Night-migrating bird collisions were the only type considered significant enough for field studies. "The wind turbine has not proved to be a high risk to airborne fauna, including the most vulnerable night-migrating songbirds. Behavioral studies indicate the birds will avoid the turbine if they can see it."

367. **\*Rosche, R.C. 1970. The fall migration: western New York and northwestern Pennsylvania. Audubon Field Notes 24(1):43-47.**

Over 300 casualties from the Elmira, New York, tower in fall 1969 are summarized. Bay-breasted warblers were the most common victims.

368. **\*Rosche, R.C. 1971. The fall migration: western New York and northwestern Pennsylvania. American Birds 25(1):54-57.**

Regular monitoring of three locations in New York and Pennsylvania in fall 1970 yielded over 2,100 avian casualties (70 species). At the Elmira, New York, tower, 220 dead birds (40 species) were collected.

369. **\*Rosche, R.C. 1972. Fall migration: western New York and northwestern Pennsylvania. American Birds 26(1):60-62.**

In the western part of the region, 313 birds (26 species) were found dead at five towers during 29-31 August 1971. At Elmira, New York, 540 casualties (55 species, mostly warblers), the highest total for fall ever recorded, were collected. Of the losses, 225 occurred on 29-30 September and 78 (kinglets, juncos, sparrows) on 25 October.

370. **Roster, T.A. 1975. Testimony on bird collision with power lines. Presented to the Public Utility Commission of Oregon, Salem, in the matter of Pacific Power and Light Company's proposed Midpoint, Idaho, to Medford, Oregon, 500-kV line. Docket No. UF-3182. 13 pp.**

This document is one person's testimony against building a 500-kV transmission line through waterfowl habitat in southern Oregon. Waterfowl behavior patterns and characteristics of their vision are discussed extensively with respect to probable collisions with power lines. Potential negative effects on local waterfowl hunting are included.

371. **Rue, L.L., III. 1957. High-tension redtails. Audubon (July-Aug.):178-181.**

In June 1956, a pair of red-tailed hawks was observed nesting on a 120-foot high transmission line tower in New Jersey. The adults did not roost on the tower with the young hawks when they were too large to brood; instead, they presumably roosted in the forest. All three young hawks fledged successfully.

372. **Russell Daily News. 1968. Rare whooping crane found near reservoir. Russell Daily News, Kansas. April 16, 1968. Page 1.**

A whooping crane in Kansas appeared to have died from either natural causes, collision with a wire, or an unknown factor. The bird had a six-foot, six-inch wingspan and weighed 12 to 18 pounds.

373. **\*Rusz, P.J., H.H. Prince, R.D. Rusz, and G.A. Dawson. 1986. Bird collisions with transmission lines near a power plant cooling pond. Wildlife Society Bulletin 14:441-444.**

This Michigan study found differences among avian species in behavior and flight patterns. Gulls exhibited a low casualty rate in collisions, tending to fly at wires and upswing as they approached. Great blue herons may not have been able to avoid objects as they approached and were more vulnerable to power line collisions. Herons often fly at dawn and dusk when visibility is poor. The authors recommend giving this species special consideration in impact analysis of proposed transmission lines near rookeries or other frequented areas. The authors felt that scavenger removal was a minor source of bias in determining casualty rate.

374. **Sanderson, G.C. and W.L. Anderson. 1981. Waterfowl studies at Lake Sangchris, 1973-1977. Illinois Natural History Survey Bulletin 32 (article 4):656-689.**

A five-year waterfowl study was conducted at power lines crossing a slag pit at the Kincaid Power Plant at Lake Sangchris in central Illinois. From 1973 to 1975, between 200 and 400 waterfowl were killed by colliding with high voltage lines. Mallards constituted 37 percent of the victims, American coots 25 percent, and blue-winged teals 17 percent. "Power lines should not be built over water unless alternate routes do not exist; lines should not cross areas where waterfowl concentrate; and visibility of lines in problem areas should be enhanced."

375. **San Francisco Chronicle. 1984. Many eagles electrocuted, study by utility finds. San Francisco Chronicle, Friday, April 27.**

The basis of this article seems to be the Electric Power Research Institute (EPRI) report on preventing golden eagle electrocutions. In the three-year study of eagle habitats in six western states -- Oregon, Idaho, Wyoming, Utah, Nevada, and New Mexico -- the carcasses of 343 electrocuted eagles were examined. The article cites a U.S. Fish and Wildlife Service study where electrocutions were responsible for 23 percent of 597 golden eagle deaths analyzed between 1963 and 1982; shootings accounted for 18 percent of those deaths.

376. **Schmidt, V.E. 1973. Okologische Auswirkungen von elektrischen Leitungen und Masten sowie daran Accessorien auf die Vogel (Ecological effects of electrical transmission lines, poles, and their accessories on birds). Beitr. Vogelkd. (Leipzig) 19(5):342-362. (In German; no translation.)**

377. **\*Schorger, A.W. 1952. Ducks killed during a storm at Hot Springs, South Dakota. Wilson Bulletin 64(2):113-114.**

On the night of 25 October 1951, in rain, snow, and fog, many ducks (mostly redheads and mallards) were killed by colliding with buildings, trees, telephone poles and wires, and other obstacles.

378. **\*Schroeder, C.H. 1977. Geese hit power transmission line. North Dakota Outdoors 40(2):inside front cover.**

Near Hankinson, North Dakota, 46 snow geese (15 white phase and 31 blue phase) were found dead near a power line on the morning of 22 April 1977. Apparently the birds struck the line early in the morning even though weather was clear, mild, and fogless.

379. **\*Scott, F.R. and D.A. Cutler. 1965. Fall migration: middle Atlantic coast region. Audubon Field Notes 19(1):21-24.**

On the night of 11 September 1964, thousands of birds were killed at a 1,000-foot tower in Baltimore, Maryland. Over 300 ovenbirds were found among the 1,032 casualties (37 species) examined. More than 100 birds (23 species) died at a Lynchburg, Virginia, ceilometer on the night of 4 October.

380. **\*Scott, F.R. and D.A. Cutler. 1971. The fall migration: middle Atlantic Coast region. American Birds 25(1):36-40.**

On 28 September 1970, 1,965 birds (43 species) died at the WBAL-TV tower in Baltimore, Maryland. Ovenbirds (489) and red-eyed vireos (410) dominated the kill. Extensive mortalities were reported from the Chesapeake Bay Bridge-Tunnel.

381. **\*Scott, F.R. and D.A. Cutler. 1972. Fall migration: middle Atlantic coast region. American Birds 26(1):41-45.**

A kill of 180 birds, mostly warblers, occurred at a Baltimore, Maryland, tower on 28-29 September 1973.

382. **Scott, J.M. and R.M. Jurek. 1985. Report to the California Fish and Game Commission on condor mortality issues, actions and recommendations. Prepared by U.S. Fish and Wildlife Service and California Department of Fish and Game. 45 pp.**

An immature condor in California experienced a fatal collision with an electrical distribution line.

383. **Scott, P. and The Wildfowl Trust. 1972. The swans. Houghton Mifflin Company, Boston. 242 pp.**

Overhead wire collision has undoubtedly been a major factor in limiting populations of swans in some areas. Some birds are killed by impact with power lines and others by electrocution. "Those which survive the collision are often stunned and fall heavily to the ground. In the absence of serious injury, they eventually recover and fly off, but for awhile they are vulnerable to foxes and other predators." Sixty-five percent of swans recovered died from collision; fifteen percent of those deaths were due to overhead wires. Swans have slow flight, low maneuverability, and poor forward vision, making them especially susceptible to collision with wires.

384. **Scott, R.E., L.J. Roberts, and C.J. Cadbury. 1972. Bird deaths from power lines at Dungeness. British Birds 65(7):273-286.**

Bird mortality was monitored from January 1964 to November 1970 along a section of power line in an area heavily used by migrants. Of the 1,285 dead birds (74 species) collected, starlings (489) and gulls (138) suffered the heaviest losses, followed by various nocturnal migrants (rails, turtle doves, thrushes, warblers). Few diurnal migrants were found. Because many carcasses were lost to scavengers, the kill may actually have exceeded 6,000. Attempts to make the wires more visible with luminous orange tape were inconclusive. A list of the casualties and the results of experiments to test scavenger removal of dead birds are given. The siting of power lines is a critical factor in the amount of mortality at a given location, and other factors such as height of migration flights and flock configuration are important in determining which species are killed.

385. **Scott, T.G. and T.S. Baskett. 1941. Some effects of the 1940 Armistice day storms on Iowa's wildlife. Iowa Bird Life 11(1):22-29.**

Following the 11 November 1940 blizzard in Iowa (with winds up to 50 mph, intermittent heavy rainfall, and rapid temperature drops), a dead ring-necked pheasant

cock was found frozen hanging from a wire fence. It had probably struck the fence while flying during the storm.

386. **Scott, W.E. 1950. Report on the convention at Two Rivers. Passenger Pigeon 12(2):69-72.**

Eighty-five dead or injured birds (33 species) were found under wires along five miles of road from Manitowoc to Two Rivers, Wisconsin, on 7 May 1950. This was "characteristic of the conditions in which migrating birds were carried out of control by the winds."

387. **\*Seets, J.W. and H.D. Bohlen. 1977. Comparative mortality of birds at television towers in central Illinois. Wilson Bulletin 89(3):422-433.**

From August to December 1972, seven towers ranging from 185 to 484 meters tall were checked for dead birds on mornings following nights of fog or overcast. A total of 5,465 dead birds (79 species) was collected, with 60 percent of the losses occurring on the night of 26 September. Most birds were killed on nights with cloud ceilings of 550 m or less. There was "no consistent relationship between tower height, terrain, or tower location and number of birds killed." It is believed that the number of birds killed on a given night is dependent on local weather conditions and the number of birds aloft.

388. **\*Serr, E.M. 1976. The spring migration: northern Great Plains. American Birds 30(4):855-858.**

Mention is made of a "wire-killed" peregrine falcon in Montana.

389. **\*Sharp, B. 1971. Heavy mortality of migrating birds at Madison's TV towers. Passenger Pigeon 33(4):203-204.**

On the night of 23 September 1968, 493 birds (33 species) were killed at four towers in Madison, Wisconsin. Weather data and kill lists are given. Thrushes, warblers, and vireos comprised 98 percent of the losses.

390. **\*Siegfried, W.R. 1972. Ruddy ducks colliding with wires. Wilson Bulletin 84(4):486-487.**

The following birds were found dead near overhead wires at Minnedosa, Manitoba, Canada: eight ruddy ducks, four American coots, two blue-winged teals, one mallard, and one pintail. Male ruddy ducks seem particularly susceptible to such accidents because they fly low when moving from pond to pond and they normally fly only at dusk on the breeding grounds.

391. **Sisson, J. 1975. Death trap. National Wildlife 13(2):18.**

At least 50 mute swans were killed between 1959 and 1974 by colliding with power lines along the Jordan River in East Jordan, Wisconsin. The lines became a "death trap" when



trees nearby that had previously diverted the birds away from the lines were cut down to build a bridge. An attempt to increase visibility by attaching large staggered wooden blocks to the lines failed.

- 392. Smith, J.C. 1985. Perching and roosting patterns of raptors on power transmission towers in SE Idaho and SW Wyoming. Raptor Research 19(4):135-138.**

"As part of an ongoing raptor management program, 45 km of 345-kV transmission lines were surveyed from 5 June to 31 September 1983 to determine diurnal and nocturnal raptor use patterns." Golden eagles and red-tailed hawks perched mostly on upper, outer sections of towers at day and roosted on lower, inner sections at night.

- 393. Smith, J.R. and J.T. Schletz. 1991. Bird/powerline collision detection system. Prepared for Pacific Gas and Electric (PG&E), San Ramon, California. Report 009.4-91.10. 25 pp. plus appendices.**

"The objective of this project is to develop hardware and techniques necessary to discriminate bird collisions with overhead conductors from other conductor vibrations, and record and analyze data under field conditions for extended periods of time." The system is a self-contained motion detection sensor that is mounted on an energized conductor and a ground station that receives and stores information collected by the sensor. It "provides a means to collect data on the potential bird mortality resulting from overhead electrical conductors....The system should be used in conjunction with direct observations of bird flights or radar evaluation of bird movements in the vicinity of the conductors."

- 394. Smith, V.M. 1961. Tower casualties at Columbia, South Carolina. Chat 25(1):18-19.**

On the last day of September and the first few days of October 1960, "hundreds" of birds were killed at the WIS transmitter tower at Columbia, South Carolina.

- 395. Smith, W.E. and M.W. Nelson. 1976. Constructing electric distribution lines for raptor protection. Proceedings of the American Power Conference 38:1294-1303.**

National Audubon Society members and associates working in the field reported over 300 eagle electrocution incidents throughout the United States in 1975. Ninety-eight percent of the birds killed were young, just learning how to fly. The authors outline several construction strategies that can help eliminate the risk of avian electrocution. Beneficial aspects of power lines for raptors are also discussed.

396. Snow, C. 1973a. Habitat management series for endangered species, report no. 5: southern bald eagle *Haliaeetus leucocephalus* and northern bald eagle *Haliaeetus leucocephalus alascanus*. U.S. Bureau of Land Management Technical Note T-N-171. 58 pp.

Causes of mortality for bald eagles include electrocution, but insufficient data are available to determine the impact of electrocutions on bald eagle populations. Electrocution fatalities are minor compared to deaths by shooting but may be considerable in some areas.

397. Snow, C. 1973b. Habitat management series for unique or endangered species, report no. 7: golden eagle, *Aquila chrysaetos*. U.S. Bureau of Land Management Technical Note T-N-239. 52 pp.

Electrocutions and collisions with power lines appear to be fairly common for golden eagles, particularly among juveniles; three-phase, four-carrier lines with less than six feet between conductors have been particularly lethal. Electrocution is a major mortality factor in some areas.

398. \*Somerset, H. 1972. Jabiru killed by power line. South Australian Ornithologist 26(3):55.

A black-necked stork was found dead beneath a power line near Darwin in southern Australia in November 1971.

399. \*Stahlecker, D.W. 1975. Impacts of a 230 kV transmission line on Great Plains wildlife. Thesis. Colorado State University, Fort Collins. 67 pp.

Wildlife censuses were conducted between 10 September 1973 and 9 August 1975 along a 230-kV transmission line in southeastern Colorado before, during, and after its construction. Avian mortality due to collisions with the transmission line and ground wire was slight: one mourning dove and five horned larks. Because other birds may have fallen on parts of the right of way that were not searched and the impact of scavengers was not assessed, losses may have been greater.

400. Stahlecker, D.W. 1978. Effect of a new transmission line on wintering prairie raptors. Condor 80:444-446.

Construction of a 230-kV transmission line extending from Colorado Springs to Limon, Colorado, affected the local distribution and number of wintering diurnal raptors as studied during pre-construction (1973-1974) and after construction (1974-1975). "Although towers were only 1.5 percent of the available perches in 1974-75, 81 percent of all perched raptors were seen on them. Rough-legged hawks, golden eagles, and prairie falcons all used towers more than all other perches combined." Both density and population of local raptors increased after line construction.

- 401. Stahlecker, D.W. and H.J. Griese. 1979. Raptor use of nest boxes and platforms on transmission towers. Wildlife Society Bulletin 7(1):59-62.**

In 1974, nest boxes and platforms were placed on a 230-kV transmission line in semi-arid plains of east-central Colorado to evaluate their use by locally breeding raptors. Nest boxes increased the local breeding population of American kestrels from a minimum of six pairs to at least 25 pairs in three years. Raptors did not utilize the nesting platforms between 1975 and 1977, possibly due to an adequate number of natural nest sites and platforms being placed too low on the towers. Management issues surrounding artificial raptor nest sites are mentioned.

- 402. Steenhof, K., ed. 1987. Snake River Birds of Prey Area: annual report. U.S. Bureau of Land Management, Boise District, Idaho. 55 pp.**

Research was done to examine the implications of communal roosting by common ravens and the operation and maintenance of a 500-kV transmission line extending from south-central Idaho to south-central Oregon. The line crosses the Bureau of Land Management's Snake River Birds of Prey Area. The study also includes monitoring of fecal deposits on insulators and evaluation of means of controlling fecal contamination.

- 403. Steenhof, K. and J.M. Brown. 1978. Management of wintering bald eagles. Prepared for Eastern Energy and Land Use Team, Water Resources Analysis Office (formerly National Stream Alteration Team), U.S. Fish and Wildlife Service. FWS/OBS-78/79. 59 pp.**

The authors advise managers to discourage construction of power lines at eagle wintering sites, especially near communal roosts. New power lines should be constructed without electrocution hazards, and some existing power line poles should be modified to eliminate hazards. Power lines can be a significant cause of mortality for eagles, especially in broad, flat valleys where natural perches are not available. (Artificial perches designed for eagles have been only partially successful.) Electrocution accidents are most likely to occur on poles that provide a good view of the surrounding terrain and on crossarms that are crosswise to prevailing winds. Raptor electrocutions occur primarily during winter when eagles concentrate near human developments.

- 404. \*Stevenson, H.M. 1956. Fall migration: Florida region. Audubon Field Notes 10(1):18-22.**

Over 2,000 birds were killed on 8-9 October 1955 at a new 660-foot tower near Tallahassee, Florida. This marked the beginning of a long-term study of bird losses at the WCTV tower.

405. **\*Stevenson, H.M. 1958a. Fall migration: Florida region. Audubon Field Notes 12(1):21-26.**

As part of an ongoing study mentioned in entry #404, 2,000 dead birds were found at the WCTV tower near Tallahassee on 4-5 October 1957. Nearly 800 died at towers in Jacksonville.

406. **\*Stevenson, H.M. 1958b. Spring migration: Florida region. Audubon Field Notes 12(4):344-348.**

Kills were reported on 4 April (228 birds) and 11 April (220) at WCTV, Tallahassee, Florida, and on 21 April (297) at Jacksonville. The composition of the kills was very dissimilar between locations, and there was low correspondence between the species composition of the kills and field observations of migrants.

407. **\*Stevenson, H.M. 1959. Fall migration: Florida region. Audubon Field Notes 13(1):21-25.**

In fall 1958, 1,149 birds died at the WCTV tower, Tallahassee, Florida.

408. **\*Stevenson, H.M. 1960. Spring migration: Florida region. Audubon Field Notes 14(4):379-383.**

Over 1,800 birds were killed at the WCTV tower, Tallahassee, Florida, during late April and early May 1960. Jacksonville reported 300 ovenbirds killed on a single night. There was no correspondence between the tower kills and field surveys of migrants in species composition.

409. **\*Stevenson, H.M. 1962. Fall migration: Florida region. Audubon Field Notes 16(1):21-25.**

During fall 1961, 1,212 birds were found dead at the WCTV tower near Tallahassee, Florida. On 17 September, 1,100-1,200 birds died at the Jacksonville towers.

410. **\*Stevenson, H.M. 1966. Fall migration: Florida region. Audubon Field Notes 20(1):30-35.**

The largest November kill ever at WCTV, 770 birds, was recorded in 1965. November kills generally consist of wintering species.

411. **\*Stevenson, H.M. 1973. The fall migration: Florida region. American Birds 27(1):45-49.**

In early October 1972, 193 birds (39 species) were killed at the WCTV tower near Tallahassee, Florida, and about 1,000 birds died at Jacksonville.

412. **\*Stoddard, H.L., Sr. and R.A. Norris. 1967. Bird casualties at a Leon County, Florida TV tower: an eleven-year study. Tall Timbers Research Station Bulletin No. 8. Tallahassee, Florida. 104 pp.**

A study begun by Stoddard in 1955 is updated through 30 September 1966. In those eleven years, over 29,000 dead birds (170 species) were collected. Most losses were in the fall. Spring kills were composed of species that bred abundantly in that area. Dangerous weather may cause differential mortality among species, sexes, and age classes.

413. **Stoner, E.A. 1939. Western red-tailed hawk nests on high voltage tower. Condor 41(1):215.**

A red-tailed hawk nest was found on a tower in Benicia, California.

414. **\*Stout, I.J. 1967. The nature and pattern of nonhunting mortality in fledged North American waterfowl. Thesis. Virginia Polytechnic Institute, Blackburg. 329 pp.**

Collisions with towers and power lines were among the causes of mortality considered in this masters thesis on mortality in North American waterfowl. A questionnaire survey, band returns, and published and unpublished reports were the sources of the data. Of mortality reported in the surveyed literature, 65 percent of the collisional losses were due to wire strikes and 4 percent to towers. Most losses to wires occurred during fall migration in inclement weather.

415. **Stout, I.J. and G.W. Cornwell. 1976. Nonhunting mortality of fledged North American waterfowl. Journal of Wildlife Management 40(4):681-693.**

Over two million cases of reported nonhunting mortality from 1930 to 1964 were analyzed. Collision mortality, including towers and power lines, accounted for 0.1 percent of the deaths and was most common in the Central Flyway (compared to the Pacific and Mississippi Flyways). Higher frequency of collisions in the Central Flyway may be due to geographical terrain. Factors that may contribute to wire strikes are migration patterns and inclement weather (especially fog). It is suggested that unnecessary fences and wires be removed from waterfowl marsh habitat to reduce collision mortality.

416. **\*Strnad, F. 1962. Birds killed at the KROC-TV tower, Ostrander, Minnesota. Flicker 34(1):7-9.**

Five kills during September and October 1961 totalled over 2,000 birds (66 species) at this 1,314-foot tower. During 3-4 September, 526 dead birds were collected out of an estimated 1,500-2,000 killed. Overcast conditions prevailed during the incidents.

417. **\*Strnad, F. 1975. More bird kills at KROC-TV tower, Ostrander, Minnesota. Loon 47(1):16-21.**

The author summarizes previous mortality at this tower and adds findings from the autumns of 1972 (185 birds, 32 species), 1973 (726, 59), and 1974 (801, 38). Complete kill lists from 1961, 1962, and the present study are given. Among the 3,507 casualties (84 species) listed, northern waterthrushes (619) and red-eyed vireos (516) were the most common. A description of the 1,300-foot tower and its lights and guy wires, details of the method of search, and weather conditions on kill nights are also provided.

418. **Switzer, F. 1977. Saskatchewan Power's experience. Blue Jay 35(4):259-260.**

The Saskatchewan Power Company recorded about 100 hawk and owl and 100 crow and magpie electrocution mortalities each year. Most of these deaths occurred on the "running corner" or "farm tap" structure where the ground point guy wire was attached 24 inches below the phase. In addition, 25-kV, three-phase rural distribution lines posed many electrocution problems, with lines on the crossarms and a phase-to-phase clearance of only three feet. The impact of habitat on mortality incidents is discussed.

419. **Tacha, T.C., D.C. Martin, and C.G. Endicott. 1978. Mortality of sandhill cranes associated with utility highlines. Pages 175-176 in: J.C. Lewis, ed. Proceedings of 2nd crane workshop, Rockport, Texas. National Audubon Society. Colorado State University Printing Service, Ft. Collins, Colorado.**

On 9 February 1978, 52 sandhill cranes were found dead or dying from impact with high voltage transmission lines and telephone lines in Texas. The transmission lines accounted for nearly nine times as many crane deaths per km as telephone lines. A sudden shift from high visibility to dense fog during the previous afternoon may have been a contributing factor.

420. **\*Tanner, J.T. 1954a. Bird mortality during night migration, October 1954. Migrant 25(4):57-59.**

This is a general summary of the widespread avian mortality that occurred in the eastern U.S. on the nights of 6-7 and 7-8 October 1954. Special emphasis is placed on weather factors accompanying the losses.

421. **Tanner, J.T. 1954b. Knoxville. Migrant 25(4):64-65.**

Following the windy, overcast night of 6 October 1954, 267 birds (26 species) were recovered at the McGhee-Tyson Airport ceilometer near Knoxville, Tennessee. The author determined that the migrating birds were attracted not only by the ceilometer beam itself, but also by the light reflected from birds flying in and about the beam.

- 422. \*Taylor, W.K. and B.H. Anderson. 1973. Nocturnal migrants killed at a central Florida TV tower: autumns 1969-1971. Wilson Bulletin 85(1):42-51.**

During the three fall seasons, 7,782 birds (82 species) were killed at the 1,481-foot WDBO tower near Orlando, Florida. The losses are listed by species in half-month intervals, and an annotated species list with sex and age information is given. One Florida yellow bat was also collected. Information on weather and lighting is included.

- 423. \*Taylor, W.K. and B.H. Anderson. 1974. Nocturnal migrants killed at a central Florida TV tower, autumn 1972. Florida Field Naturalist 2(2):40-43.**

During the fourth season of monitoring losses at an Orlando, Florida, tower, 1,347 birds (49 species) were collected, 89 percent of them warblers. The four-year total losses were 9,130 birds (89 species). A kill list for fall 1972 is provided by half-month periods. This tower collapsed in June 1973.

- 424. \*Teulings, R.P. 1972. The fall migration: southern Atlantic coast region. American Birds 26(1):45-50.**

Two towers were checked regularly for casualties during fall 1971. The 1,960-foot WECT tower at Bladen County, North Carolina, totalled 1,706 dead birds (75 species), and the 1,250-foot WWAY tower at Boiling Springs, North Carolina, accounted for 970 (with 958 on a single night). Partial kill lists and unusual records are given for the seven largest single-night kills. Warblers predominated overall.

- 425. \*Teulings, R.P. 1974. The fall migration: southern Atlantic coast region. American Birds 28(1):37-40.**

A major kill consisting of about 600 casualties was reported from the WECT tower in Bladen County, North Carolina, on the night of 30 September 1973.

- 426. \*Teulings, R.P. 1975. The fall migration: southern Atlantic coast region. American Birds 29(1):40-43.**

An estimated 4,000 birds were killed on the night of 4 September 1974 at a tower in Bladen County, North Carolina.

- 427. Thomas, C.B. 1977. The mortality of Yorkshire Canada geese. Wildfowl 28(1):35-47.**

From 1963 to 1975, 4.3 percent of 553 recovered Yorkshire (England) Canada geese were recorded as dead from wire collision. Most of the rest had been shot.

428. **\*Thompson, L.S. 1977. Overhead transmission lines: impact on wildlife. Montana Department of Natural Resource and Conservation, Energy Planning Division, Helena. Research Report No. 2. 51 pp.**

"This report provides an overview of the potential impacts of transmission lines upon wildlife, and suggestions on how impacts of new lines may be prevented or mitigated." Among the topics addressed are bird losses due to strikes and electrocutions at power lines. An extensive bibliography is included.

429. **\*Tordoff, H.B. and R.M. Mengel. 1956. Studies of birds killed in nocturnal migration. University of Kansas Publications, Museum of Natural History 10(1):1-44.**

This is an extensive analysis of 1,090 birds (61 species) killed at the 950-foot WIBW TV tower in Topeka, Kansas, during fall 1954. The losses are listed by date collected, and an annotated species list gives weights, fat conditions, and sex-age data. The author notes the kill was "not at all random" with respect to the actual relative abundance of species, since some birds (*e.g.*, shorebirds) were common in the field but uncommon in the kill. However, an estimate is made of the volume of migration through the area by assuming the tower took a random sample of the overall migrant population. Differential migration by sex and age is discussed in certain species as are differences in wing length, tail length, and weight.

430. **\*Trauger, D.L., A. Dzubin, and J.P. Ryder. 1971. White geese intermediate between Ross' geese and lesser snow geese. Auk 88(4):856-875.**

A mention is made of 131 lesser snow and blue geese that struck a power line near Craig, Missouri, in March 1966. No details are given.

431. **\*Trott, J. 1957. TV tower fatalities at Chapel Hill. Chat 21(1):28.**

An estimated 2,500 birds (44 species) were killed on 28 September and 3 October at a 788-foot tower in North Carolina. Low cloud ceilings accompanied the incidents. A kill list is given.

432. **\*Turner, J. 1971. Eagles: vanishing Americans? Sierra Club Bulletin 56(9):14-19.**

The author states that illegal shooting, poisoning, and power line electrocutions cause considerable eagle mortality in western states. Sixteen eagle deaths were attributed to power lines near Worland, Wyoming, in 1971. In the Escalante Desert, Utah, 40 dead eagles (10 with "white heads") were found beneath a 12-mile stretch of power line. An additional 54 eagles were reported killed by power lines in Colorado's Pawnee National Grasslands and Moffat County. Eagles using utility wires and poles as perch sites are sometimes shot.



433. **Ultrasystems, Inc. 1985. Potential effects of the proposed Fayette Manufacturing Corporation Bald Mountain wind energy project on the California condor: preliminary draft report. Submitted by Ultrasystems Inc., Environmental Systems Division, Irvine, California. Submitted to Fayette Manufacturing Corporation, Tracy, California. 37 pp.**

Wind turbine collision is a principal issue concerning the California condor. "The loss of a single individual is considered significant by persons associated with the recovery effort" because of the bird's critical status. A table of persons contacted regarding wind farm development effects on raptors and other biota is given.

434. **United States Fish and Wildlife Service. 1978. U.S. Fish and Wildlife Service position regarding overhead power and communication lines. 4 pp.**

No new overhead power or communication lines will be permitted on National Wildlife Refuges unless compatible with the purpose of the refuge and approved in writing by the Regional Director. Wherever possible, existing overhead lines will be removed or modified to achieve this compatibility.

435. **Urban Wildlife Research Center, Inc. 1980. Compatibility of fish, wildlife, and floral resources with electric power facilities and lands: an industry survey analysis. Prepared for the Edison Electric Institute, Washington, D.C. 130 pp.**

Birds' use of poles, towers, and transmission-distribution system lines are discussed as part of their habitat. An estimated 300 waterfowl were killed from September to December 1974 when they collided with power lines in Christian County, central Illinois. The lines crossed a slag ash pit adjacent to a power plant and Lake Sangchris. Recommendations for reducing mortalities include installing structural devices such as nest boxes, perches, feeders, and platforms for raptors and other birds.

436. **Vian, W.E. 1971. The wintering bald eagle (*Haliaeetus leucocephalus*) on the Platte River in southcentral Nebraska. Thesis. Kearney State College, Kearney, Nebraska. 60 pp.**

A bald eagle was killed by power line collision.

437. **Vosburgh, J. 1966. Deathtraps in the flyways. Pages 364-371 in: A. Stefferud, ed. Birds in our lives. U.S. Department of Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife.**

Mortality of migrants at towers and tall buildings is reviewed.

438. Waco, D. and M.D. Batham. 1984. Wind resource assessment of California: a summary of CEC-sponsored studies. California Energy Commission Staff Report P500-83-019. Sacramento, California. 20 pp.

In 1977, an extensive series of wind resource assessment studies was begun by the California Energy Commission (CEC) to identify the locations and extent of potential wind energy areas. "The Energy Commission studies indicate that California possesses one of the most abundant and developable wind resources in the world." Although avian mortality problems had not yet been identified, this document offers information on locations of California's wind resource.

439. \*Walker, A. 1916. Some raptores [sic] of Douglas County, South Dakota. *Condor* 18(3):130.

A golden eagle was killed by flying into a wire fence near Delmont, South Dakota, on 11 November 1911.

440. \*Walkinshaw, L.H. 1956. Sandhill cranes killed by flying into power line. *Wilson Bulletin* 68(4):325-326.

Along the North Platte River in Nebraska, five sandhill cranes were found dead beneath 30-foot high power lines on the morning of 22 March 1954. They had apparently flown into the lines at or before dawn.

441. Walton, B.J. and C.G. Thelander. 1983. Wild nest management, hack sites, and cross-fostering operations, 1983. Santa Cruz Predatory Bird Research Group, Environmental Field Program, University of California, Santa Cruz.

On the day of its release (7 July 1982), a hacked male peregrine falcon was killed flying into a building. The bird had been released from the 21-story office building in the Westwood area of Los Angeles.

442. \*Weaver, D.K. and R. St. Ores. 1974. Trumpeter swan mortality. Pages 86-89 in: *Proceedings and Papers of the Trumpeter Swan Society Conference*, Martin, South Dakota, 18-20 September 1973.

Collisions with fences and telephone and power lines caused the deaths of 14 swans at four refuges and parks in the western and midwestern United States during 1958-73. This was 19 percent of the total recorded mortality. Shooting was also noted as a major cause of death.

443. \*Weir, D.N. 1971. Mortality of hawks and owls in Speyside. *Bird Study* 18(3):147-154.

Of 74 dead or seriously injured birds examined during 1964-69 in this British study, 33 suffered injuries through collisions with human-made objects, including overhead wires, windows, moving vehicles, and trains.

444. **\*Weir, R.D. 1974. Bird kills at the Lennox generating plant, spring and autumn 1974. Blue Bill 21(4):61-62.**

Floodlights illuminating the 650-foot chimneys of the Ontario, Canada, power plant were dimmed from 15 April to 8 June and from 9 August to 2 October 1974, but birds were still killed, with 92 casualties in the spring and 1,188 in the fall (35 species overall). Since the first chimney was built in fall 1972, 5,288 birds were killed. In 1974, 98 percent of the casualties were warblers and vireos, with magnolia warblers (33 percent) and red-eyed vireos (11 percent) the most common casualties. Large kills occurred on the clear nights of 13-14 September (501 killed) and 14-15 September (508 killed). On both nights, winds were strong and flight call counts indicated that birds were flying lower than usual. Migrants were easily seen in the glow of city lights. In another incident on the weekend of 15 September, 1,524 birds were killed at a new 1,200-foot tower in Barrie, Ontario. Lists of casualties by date of collection and a summary of flight call counts and weather conditions are given.

445. **\*Weir, R.D. 1976. Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. Canadian Wildlife Services, Ontario Region, Ottawa. 85 pp.**

A 28-page introduction to this bibliography summarizes what is known about bird migration and the effects of weather on migration and mortality. It also includes a literature review on bird losses at lighthouses, ceilometers, floodlit obstacles, towers, tall buildings, and telephone and power lines. A list of TV towers of various heights throughout the United States is included. "Nocturnal bird kills are virtually certain wherever an obstacle extends into the air space where birds are flying in migration. The time of year, siting, height, lighting and cross-sectional area of the obstacle and weather conditions will determine the magnitude of the kill." Four hundred seventy-one references, most with brief descriptions, are included.

446. **\*Weir, R.D. 1977. Bird kills at the Lennox generating station, spring and autumn 1977. Blue Bill 24(4):40-42.**

For the sixth straight year, kills were reported at the chimneys of the Ontario Hydro plant at Bath, Ontario, Canada. The total of 2,699 (61 species) casualties, of which 2,575 were fall migrants, was the largest since the first chimney was constructed in 1972. Due to a change in floodlighting procedures, the lights were inadvertently left on during nights of heavy migration and several large kills resulted. On 23 August, 908 birds were killed under overcast skies before the lights were extinguished at 0117. Similarly, 1,172 birds died on the night of 19 September, during a driving rain. The lights were not turned off until 0500. The sky was clear on the night of 12 September and the floodlights were not used, partly in response to the public reaction to the kills that were reported in the *Toronto Globe and Mail*. The system of turning off floodlights during the spring and fall migration periods was in force prior to 1977 and will be resumed beginning spring 1978. A complete list of casualties is provided, and the 11,230 casualties recorded since fall 1972 are totalled by season.

447. **\*\*Welles, M. 1978. TV tower kill at Elmira. *Kingbird* 28(3):159-161.**

The bird mortality during 20-24 September 1977 at the WSYE TV tower, Elmira, New York, is documented. Weather during the period was rainy with low cloud ceilings. Daily kills for the five dates were 1,817, 1,358, 375, 132, and 180, respectively, totaling 3,862 birds of 44 species. Many more birds were killed but were not recoverable from fields and wooded areas surrounding the tower which is supported by 30 guy wires. Some carcasses were taken by crows. Bay-breasted warblers (1,226), Tennessee warblers (375), magnolia warblers (326), ovenbirds (311), and Swainson's thrushes (218) were the most numerous species. A Syracuse, New York, tower reported reduced losses following the installations of two telephone relay towers nearby.

448. **Western Area Power Administration. 1992. California-Oregon Transmission Project waterfowl mitigation plan. Western Area Power Administration and Transmission Agency of Northern California. Sacramento, California. 65 pp.**

This account reviews literature on bird collisions and transmission lines. "Almost all collisions reviewed involved birds striking thin overhead groundwire(s) located above the heavier conductors. No study reviewed found losses to have any biological significance to the population as a whole, although a few instances did occur where losses of individuals belonging to rare species were considered significant." The difficulties encountered in evaluating actual losses and their significance are discussed. The literature was "universal" in recommending groundwire removal whenever possible as the best means of reducing bird collisions. The second best mitigation measure was marking groundwires, as with aircraft warning balls or air flow spoilers; strikes were reduced almost 50 percent on average when groundwires were adequately marked. Waterfowl behavior in transmission line areas is examined including different species' behavioral tendencies and flight altitudes and impacts of inclement weather.

449. **\*Weston, F.M. 1966. Bird casualties on the Pensacola Bay Bridge (1938-1949). *Florida Naturalist* 39(2):53-54.**

Irregular checks of the bridge produced 740 dead birds (75 species) during the twelve-year period. Kills occurred only in the fall; power cables above the roadway of the bridge apparently caused the mortalities. The cables were removed in 1949, and a new bridge with well-lit structural parts proved no hazard to birds.

450. **Wheeler, R.H. 1966. Sandhill crane casualties in the blizzard of March 22, 1966. *Nebraska Bird Review* 34(4):69-70.**

Sandhill cranes were killed in a blizzard in Nebraska on 22 March 1966 when they collided with power lines and trees. The author expresses that "[w]e have the technology to put these lines underground in areas where waterfowl concentrate, especially in those known locations where high losses recur year after year."

451. **\*Whelan, P. 1976. The bird killers. Ontario Naturalist 16(4):14-16.**

Known sites of bird mortality in Toronto, Canada, are reviewed. Forty buildings and two towers are listed, including an 1,815-foot tower where 274 dead and injured birds were found on 30 August 1976. (This article was reprinted from the *Toronto Globe and Mail*, 17 September 1976).

452. **\*\*Wiese, J.H. 1977. A study of the reproductive biology of herons, egrets, and ibis nesting on Pea Patch Island, Delaware: report for the period March through September 1976. Delmarva Power and Light Company, Wilmington, Delaware. 179 pp.**

Aspects of the reproductive biology of herons, egrets, and ibises nesting on Pea Patch Island, Delaware, are presented. The study evaluated the possible effects of a proposed 500-kV power line crossing the Delaware River about one mile north of the heronry. Major flight routes for each species were determined throughout the 1976 nesting period. Walking surveys failed to reveal wire-induced wading bird mortality under a nearby high-voltage power line.

453. **\*\*Wiese, J.H. 1979. A study of the reproductive biology of herons, egrets, and ibis nesting on Pea Patch Island, Delaware: final interpretive report. Delmarva Power and Light Company, Wilmington, Delaware. 255 pp.**

The results from the final segment (1 March to 28 October 1978) of a four-year study on the effects of a 500-kV transmission line across the Delaware River on the Pea Patch Island heronry are presented. No collisions with the 500-kV line were observed. In 1978, wading birds had several conductor collisions and numerous near-misses at a 138/230-kV line at a second site studied. Multi-level conductor configuration at this line was more problematic than the single-level conductors which the birds crossed with little hesitation. No dead or injured birds were found beneath the 138/230-kV lines. In general, wading birds approaching and crossing power lines appeared "highly cognizant" of the obstacles and typically changed flight speed, altitude, or direction of approach when flying at conductor heights. The presence and operation of the 500-kV power line were judged not likely to adversely affect the stability of the Pea Patch Island heronry or the nesting success of wading birds therein.

454. **Willard, D.E. 1977. Hearing on waterfowl report. Testimony to the Public Utility Commissioner of Oregon concerning Pacific Power and Light Company's proposal for a 500-kV transmission line. Salem, Oregon. 35 pp.**

In his testimony on the effects of power lines on waterfowl, Willard states that, prior to power line installation, complete analysis of surrounding habitat and species composition is necessary. Special attention should be given to birds such as pelicans, which forage while flying and are less likely to notice overhead wires, and Ross' geese, which fly tightly grouped together and are at high risk for collision if a flock enters a wired area.

455. \*Willard, D.E., J.T. Harris, and M.J. Jaeger. 1977. The impact of a proposed 500-kV transmission route on waterfowl and other birds. Oregon Public Utility Commission, Salem, Oregon. 89 pp.

From October 1976 to April 1977, a study was conducted to determine the potential impact of a proposed power line through areas used by waterfowl, pelicans, cranes, and other birds in the Klamath Basin, Oregon. Data were collected on flight height, weather conditions, and movement patterns as well as on mortality along existing lines. The following conclusions are listed: (1) large birds such as pelicans and swans are particularly vulnerable to collisions with overhead wires; (2) flying low to the ground under conditions of strong winds and poor visibility increase the possibility of strikes occurring, although birds run into wires regularly even in clear, calm, bright weather; (3) the impact on easily-found species is usually an overestimate; and (4) scavenging, though it occurs, is probably trivial.

456. Willard, D.E. and B.J. Willard. 1978. The interaction between some human obstacles and birds. *Environmental Management* 2(4):331-340.

The history of avian interactions with human obstacles is discussed, citing various studies. Willard and Willard researched the non-lethal effects of power lines, such as how birds alter flight patterns in response to obstacles. TV towers can cause a high number of mortalities in a short amount of time, and "though this problem has often not been documented, it is widespread." The authors note that Mayfield (1967) felt that the frequency of death is correlated to the frequency of that species' occurrence; however, the percent distribution of power line-caused fatalities is probably more than Mayfield predicts because "the amount of area over which utility lines may cause death or injury is immense, so that a large effect could be scattered so widely that each case is not notable."

457. Willdan Associates. 1982. Impact of the Ashe-Slatt 500-kV transmission line on birds at Crow Butte Island: postconstruction final report. Prepared by Willdan Associates, Portland, Oregon. Prepared for Bonneville Power Administration, Portland, Oregon. 155 pp.

This postconstruction report of a 500-kV line focuses on flight observations near the line, bird use of habitat in the line vicinity, dead bird searches, estimates of total collisions, and evaluation of an electronic collision sensor. In the two years following construction, an estimated 46 ducks were killed by line collision; 33 ducks were killed at the study site in the third year of research. "Overall, the number of waterfowl killed from wire strikes...is very small compared with the total regional population and the number of birds crossing the lines in the study areas." Waterfowl habitat use was significantly reduced by the transmission line.

458. Williams, R.D. and E.W. Colson. 1988. Associations of western raptors with linear rights-of-way. Pacific Gas and Electric (PG&E), San Ramon, California. 49 pp.

Benefits of rights-of-way (ROW) are discussed, including provision of migratory corridors for open-land raptors (red-tailed hawks and northern harriers) and the increase of nesting, perching, and roosting sites offered by power line towers. "Although collision mortality can be significant to waterfowl, shorebirds, and upland game birds, it does not appear to pose a major problem for raptors. However, raptors can be susceptible to collision problems with power lines during times of distractions such as when involved in prey pursuits, courtship flights, and territorial defense. Also raptors are susceptible to collision with lines during inclement weather.... Overhead wires, unlike most other linear ROW, encroach on air space used by raptors ... and create many unique hazards." Some evidence suggests that birds may become habituated to the presence of a line, resulting in fewer collisions over time.

459. Williams, R.D. and E.W. Colson. 1989. Raptor associations with linear rights-of-way. Pages 173-192 in: B.G. Pendleton, ed. Western Raptor Management Symposium and Workshop, Boise, Idaho, 1987. National Wildlife Federation Scientific and Technical Series #12.

Linear rights-of-way (ROW) include those for electric power lines and communication lines. At least 32 raptor species in the western United States are known to have been influenced by linear ROW. Tables and overviews of known adverse and beneficial impacts of ROW on western raptors are included. "Benefits provided to many raptors include preservation of habitat, provision of nest and perch sites, and increased availability of prey. The primary adverse impacts of linear ROW are loss and modification of habitat, collisions with overhead wires and automobiles, electrocutions, and increased harassment and persecution by humans." Recommendations for raptor protection include avoiding construction in sensitive habitat areas, adjustments of construction schedules and methods, and engineering modifications on power and communication lines.

460. Wilmore, S.B. 1974. Swans of the world. Taplinger Publishing, New York.

The cause of death was diagnosed for 1,051 of 2,156 mute swans recovered in Britain between 1960 and 1965, and "the greatest danger to their mortality was reported to be collision with overhead wires." During two months in 1963, a quarter-mile stretch of power line in Kent killed 21 swans, 30 percent of the total flock. Swans' weak frontal vision was noted as a contributing factor.

461. Winkelman, J.E. 1985. Bird impact by middle-sized wind turbines on flight behavior, victims, and disturbance. *Limosa* 58:117-121. (In Dutch; English summary.)

In the fall and winter of 1983-84, possible impact of medium-sized wind turbines on birds was studied at six sites in the coastal areas of Holland. Changes in flight behavior that could be attributable to the turbines were observed; no collisions were seen. The

results cannot be extrapolated to predict the danger of collisions at night or in daylight during inclement weather; the hindrance caused by other types of turbines (particularly large ones), by turbines at sites in open fields, or by large groups of wind turbines; or the risk at sites other than those studied.

- 462. Winkelman, J.E. 1992a. The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 1: collision victims. DLO-Instituut voor Bos- en Natuuronderzoek. RIN-rapport 92/2. 4 volumes. (In Dutch; English summary.)**

An experimental wind park consisting of 18 wind turbines (300-kW, three-bladed, 35 m tower height, 30 m rotor diameter), seven meteorological towers, and three control buildings, was studied between 1984 and 1991. A series of reports was published on avian mortality in the park (entries #462-465). In this study on collisions, avian collision rates increased with an increase in the number of operating turbines. Carcasses were found distributed over most of the park with a slightly lower concentration of carcasses in the middle section, suggesting that cluster formations of turbines may reduce collision risk compared to straight line or single row formation. Most collision victims were found in autumn and spring and after nights with poor flight and visibility conditions.

- 463. Winkelman, J.E. 1992b. The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 2: nocturnal collision risks. DLO-Instituut voor Bos- en Natuuronderzoek. RIN-rapport 92/3. 4 volumes. (In Dutch; English summary.)**

In this portion of the study (see also entries #462-465), researchers observed a collision rate of 68 birds per week at night. The difference in the number of mortalities observed at the moving turbines compared to those calculated indicated that a proportion of birds may have disappeared through predation or were missed due to insufficient searching. Mortality rates may have been even higher due to uncounted birds that may have collided with a turbine, flown away and died later. Illumination of the turbines was not recommended: in conditions of "poor visibility...the illumination may even attract birds, which may increase the risk of collision."

- 464. Winkelman, J.E. 1992c. The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 3: flight behavior during daylight. DLO-Instituut voor Bos-en Natuuronderzoek. RIN-rapport 92/4. 4 volumes. (In Dutch; English summary.)**

In this report (see also entries #462-465), the flight behavior of birds approaching the park in daylight is discussed and avian flight paths examined. Comparisons of bird behavior during operation and non-operation are given.



- 465. Winkelman, J.E. 1992d. The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 4: disturbance. DLO-Instituut voor Bos- en Natuuronderzoek. RIN-rapport 92/5. 4 volumes. (In Dutch; English summary.)**

In this portion of the 1984-1991 experimental wind park study (see also entries #462-464), disturbance effects of the wind park on avian breeding, feeding, resting, and migration are discussed.

- 466. \*Wray, D.L. 1960. Parasitic jaeger at Raleigh TV tower. Chat 24(4):97-98.**

An individual parasitic jaeger, an unusual species, was found dead on 26 August 1960 at a TV tower in Raleigh, North Carolina.

- 467. \*Zimmerman, D.A. 1975. The changing seasons. American Birds 29(1):23-28.**

In fall 1974, thousands of birds died at TV towers in nine states and two Canadian provinces, and 150 birds were killed at a 600-foot smokestack at a New Mexico smelter.

- 468. Zimmerman, D.R. 1976. The bald eagle bicentennial blues. Natural History 85:8-16.**

An eagle was electrocuted in Florida when it collided with a power line while carrying a fish.

**\* From Avery, M.L., P.F. Springer, and N.S. Dailey. 1978. Avian mortality at man-made structures: an annotated bibliography. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-78/58. 108 pp.**

**\*\* From Avery, M.L., P.F. Springer, and N.S. Dailey. 1980. Avian mortality at man-made structures: an annotated bibliography (revised). U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team. FWS/OBS-80/54. 152 pp.**



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